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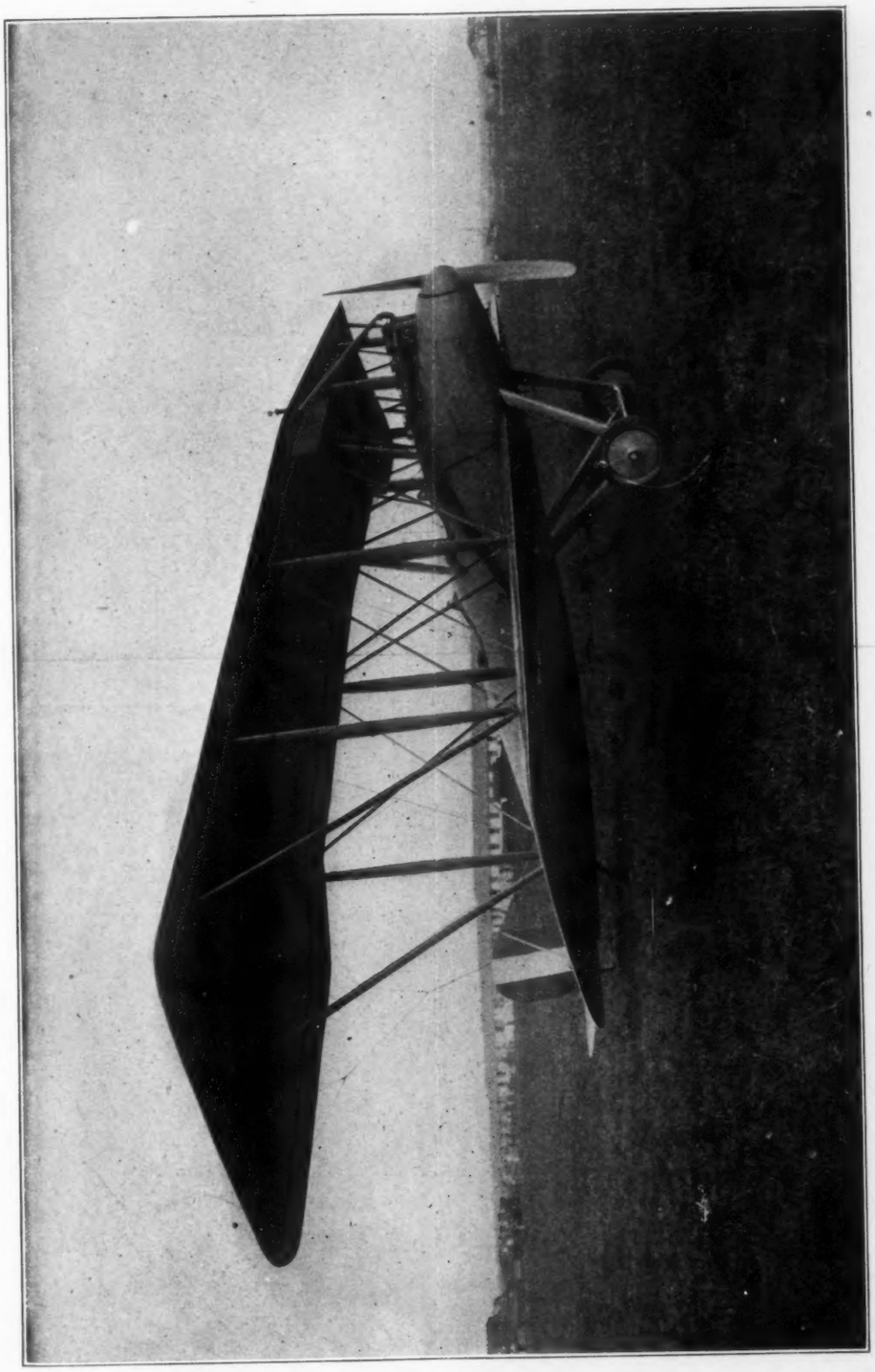

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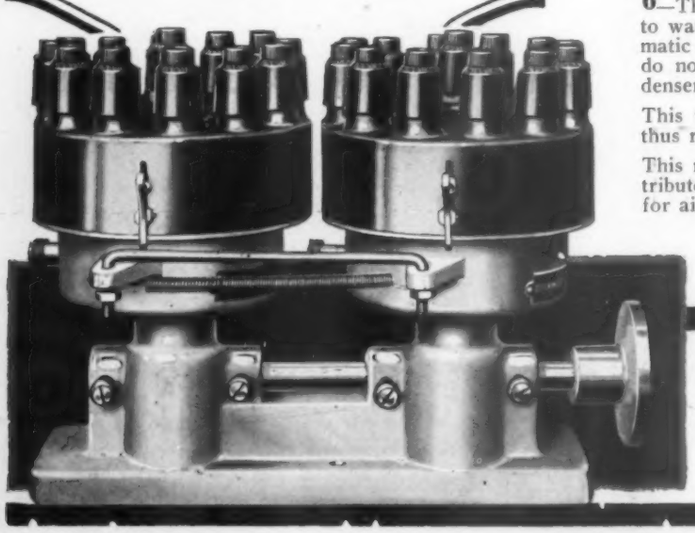

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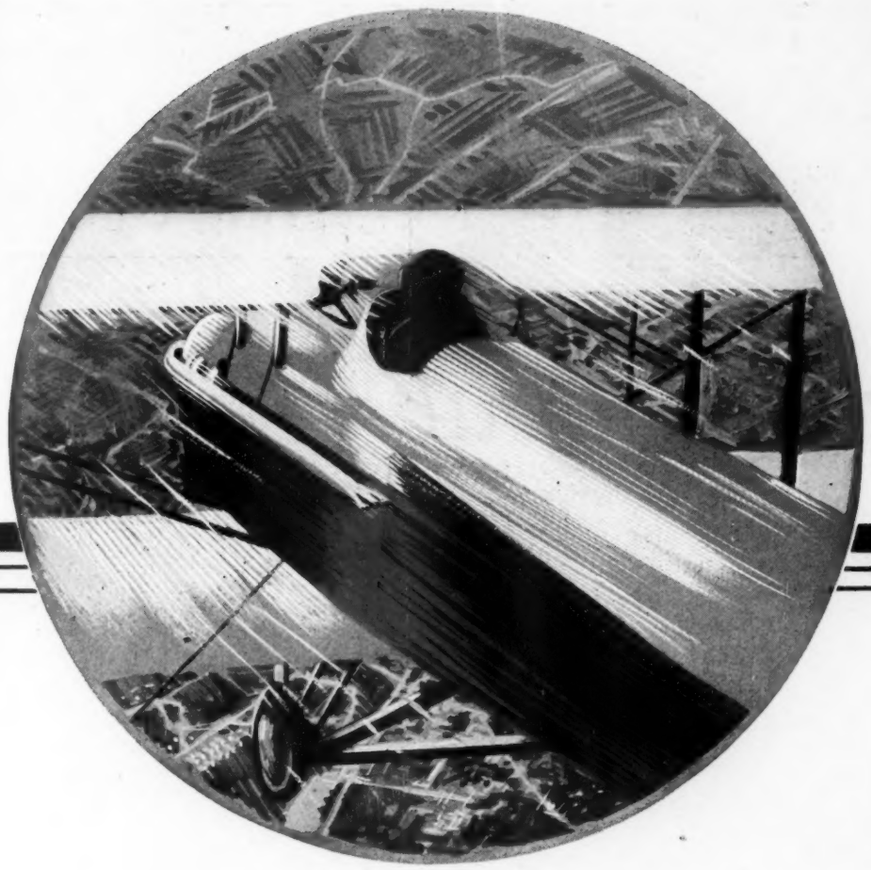

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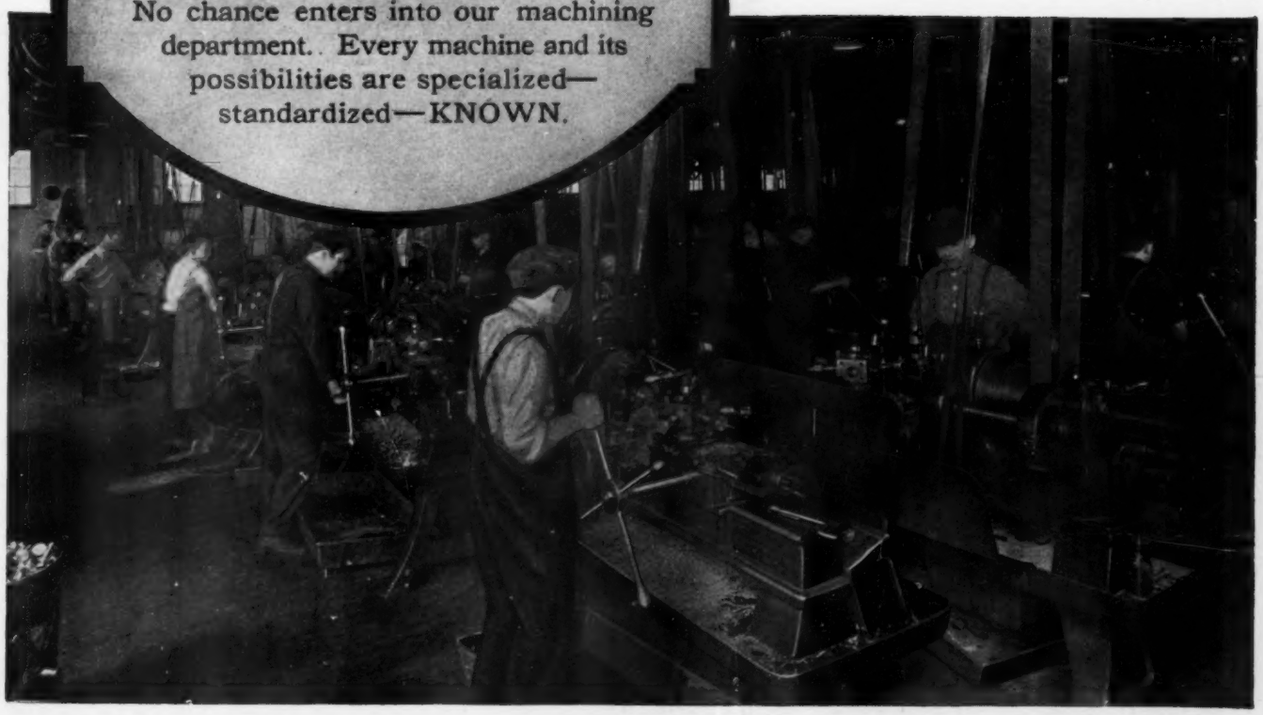

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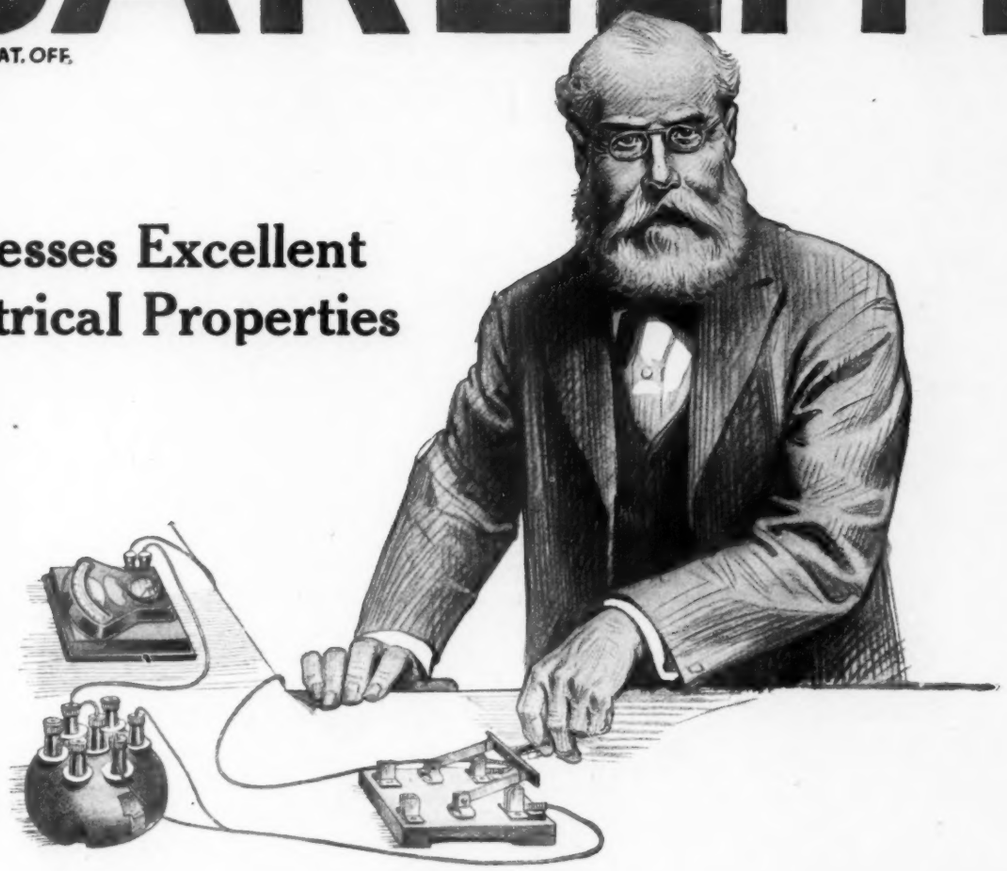

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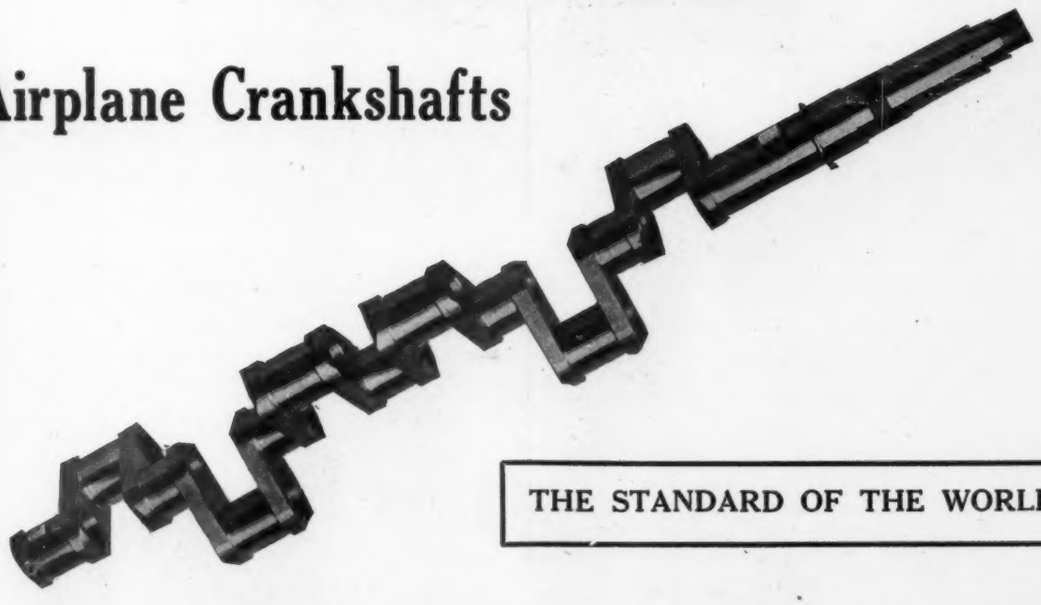

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Vol. V | September 1, 1918 | No. 3

Aircraft Production in the United States

Report of the Sub-Committee to the Senate Committee on Military Affairs

After having been engaged in another investigation of a phase of the aircraft situation since the first part of June, the report of the sub-Committee on Military Affairs, headed by Senator Thomas, was submitted to the Senate on Aug. 22. Other members were Senators Reed (Mo.), Smith (Ga.), New (Ind.) and Frelinghuysen (N. J.). The committee has found much to condemn, and some things to commend and has not hesitated at favorable or unfavorable criticism wherever it seemed to them to be deserved.

On the other hand, the report discloses little which is really new except in some added detail.

Its recommendation for the creation of an independent Air Secretary, with a seat in the Cabinet, is likely to arouse antagonism, but there are other recommendations which are acknowledged valuable on their face and will be less disputed.

Salient Features

Among the salient features and recommendations are the following:

A substantial part of the $640,000,000 appropriation was practically wasted.

Up to July 1 only 67 of 601 American-made DH-4 machines had reached the battle front.

Tests of forty DH-4's proved them structurally weak and defective. These are to be replaced with a De Haviland type of later design.

Contracts were let for 8,500 DH-4's, upon which work was stopped until numerous defects in design and workmanship could be remedied.

Over $6,500,000 was expended on the Bristol fighter, which was then condemned and its production discontinued.

After more than 1,200 Standard J training machines at a total cost of $6,000,000 had been produced, they were condemned and stored.

An order for 3,000 Spad *chasse* was subsequently canceled on the ground of obsoleteness, yet afterward a contract was placed for 1,000 equivalents, and this country is now buying every French Spad it can secure.

This contract was canceled because the Aircraft Board desired to equip the Spads with the Liberty-8, which was not practicable. At about this time the Liberty-8 itself was discarded.

Only SE-5's and Handley-Page machines can be put in quantity production before 1919.

Airplane Contracts

A contract placed for 500 Capronis was not carried out, because the manufacturer could not obtain the information. It was canceled later, and a contract for the Bristol fighter was substituted.

Only one experimental Caproni bombing plane, equipped with Liberty engines, has been built in this country, although the necessary data and facilities have been in hand since October, 1917.

Plans for the Handley-Page bombers were ready last summer, but a sample plane was not completed until a year later.

There is at the front not one American-made *chasse* and not one American-made heavy bombing plane.

The United States has neither developed nor produced in quantity a successful fighting plane.

These disappointing results are ascribed to automobile and other manufacturers who though unacquainted with aeronautical problems controlled the aircraft program and subordinated it to the creation of the Liberty engine instead of carrying on its production at the same time with the reproduction of approved European types.

Such mistakes would have largely been avoided had production been made subordinate to one man, assisted by trained aeronautical engineers to design machines and practical fliers to test them.

Organization under the Aircraft Board was unsystematic and inefficient, hindering production and yet diffusing responsibility therefor.

Colonels Clark's and Bolling's report recommending the production of English, French and Italian planes was unheeded by the Board.

Hundreds of changes in the redesign of the British fighter by Colonel Clark were made by authority of the Signal Corps without consulting him.

Americans at the front are using many antiquated machines discarded by the French eighteen months ago. Many of them are unsafe or unreliable.

Liberty Engines

The Liberty-12 is too heavy and powerful for the lighter types of planes and is not yet perfected. More than 4,000 have been delivered.

The notion that the Liberty engine could be used on all sizes and types of airplanes was encouraged and is largely responsible for the delay in the aircraft program.

No fighting plane of American or other design has been built around the Liberty engine. Our air program will not be complete until this is accomplished.

Contemporaneous manufacture of the best foreign engines with that of the Liberty, as we are now doing, should have been begun a year ago.

Manufacture of the Rolls-Royce engine by American concerns should long since have been for the American rather than for the British Government.

Inspection system of the Signal Corps functioned badly and condemned defective material has found its way back to the producer.

Colonel Deeds is criticized for establishing a flying field at Miami without the knowledge and sanction of the division having charge of the work; for a night-flying route between Dayton and Rantoul, and for financial interests in land at Dayton prior to negotiation for its lease as a flying field for the Government.

The site of Wilbur Wright Field is condemned as low and marshy.

To the civilian personnel of the Aircraft Board and its more prominent subordinates identified with industrial development in their respective communities is ascribed the favoritism alleged to have been shown in the awards of contracts.

Cross-Licensing Disapproved

Cross-licensing is disapproved by the committee and is condemned by every airplane manufacturer who outside of its immediate beneficiaries have executed license agreements under protest because recommended or required by the Aircraft Board.

Under Mr. Ryan and General Kenly the loose ends of the former organization are being gathered with some improved conditions already apparent.

Unification of the Army and Navy air services under a common head, with a seat in the Cabinet, is advocated.

A commission of engineers and pilots for observation at the front and reporting regularly to the proposed new department similar to that maintained by the Allies is recommended as imperative.

Production of planes and engines in continuing quantity by the constructive activities of all responsible concerns to full capacity is the prime need of the hour.

College and university courses in aerodynamics and mechanical engineering and in training for fliers should be established at Government expense.

An Inventions Section of the War Department is commended as a step in the right direction for giving prompt consideration to new devices and suggestions.

Ample protection should be extended by the Patent Office to applications for aircraft inventions.

Profits on some contracts for engines and planes are too high.

Producers should be required to bear the expense of planes and engines rejected, because of defective construction or materials not furnished direct by the Government.

Compulsory and better protection against fire in airplane factories is urgently recommended.

In full the report is as follows:

THE REPORT

On April 6, 1917, the United States entered the war.

On June 8, 1917, public announcement was made that a great fleet of 25,000 airplanes was about to be created, and would be decisive of the war months before an effective army could be put in Europe.

July 24, 1918, Congress appropriated $640,000,000 to carry out the aircraft program. This fund has been, either by actual expenditure or by commitments, exhausted. A further appropriation of $884,304,758 has been found necessary.

In the opinion of the committee a substantial part of the first appropriation was practically wasted.

While much good work has been accomplished, for which due credit should be given, it must nevertheless be admitted that our airplane program has, up to the present, presented many aspects of failure. To some of these we call attention:

The Situation

While an army of three and one-half million has been raised, the aircraft situation is as follows:

(*a*) Six hundred and one De Haviland-4's have been embarked for France up to August 1, 1918.

Of these, 67 had reached the front by July 1.

On August 7 a squadron of 18 De Haviland-4's flew over the German lines. Details of its performance have not been received. The character and construction of the De Haviland-4 is further discussed in paragraph (*i*) and in the body of this report.

(*b*) We have not a single American-made *chasse* (or plane of attack) upon the battle front.

(*c*) We have not a single American-made heavy bombing plane upon the battle front.

(*d*) We have not developed and put in quantity production a successful *chasse*, or fighting plane.

(*e*) Our attempt to create a fighting plane was centered in an attempt to adapt the Bristol fighter and De Haviland to the Liberty motor. The Bristol was, without sufficient tests, put in quantity production, over $6,500,000 expended, and the lives of several gallant men sacrificed, when the machine was condemned and its manufacture discontinued.

(*f*) The Standard-J training machine was equipped with the Hall-Scott engine and put in quantity production. After more than 1,200 had been manufactured at a cost of $6,000,000 the machine thus equipped was condemned as dangerous and placed in storage.

(*g*) The Spad is a *chasse* or fighting plane of the highest type. Early in September an oral order was given to the Curtiss Company for the manufacture of 3,000 of these machines. Work was at once begun and drawings practically completed.

On September 27, Colonel Clark and Major Vincent (one of the inventors of the Liberty motor), concluded that the machine could not be operated with a Liberty motor.

October 8 the contract was canceled, the reason given being that the single-seat fighter was regarded as obsolete. But the fact is that on April 23, 1918, a contract was let to the Curtiss Company to build 1,000 single-seat fighters, known as the SE-5, which is the English equivalent of the French Spad.

In addition to this, our Government is now using upon the battle front every Spad machine it can secure from the French, but has only been able to obtain about 418 of them.

(*i*) The cancellation of the Spad contract and the failure of the Bristol left us without either a single or a two-seat fighter. Except the De Haviland-4, which was originally designed as a two-seat fighter and which we are equipping for reconnaissance, photographic, bombing and fighting purposes.

Contracts for 8,500 were let at various times. Up to August 1, 1,000 had been delivered, and a number forwarded to General Pershing. An inspection and test developed numerous mistakes, both in design and workmanship. Work upon the planes was stopped until the defects could be remedied. In

part this appears to have been accomplished in the field, for a squadron of 18 planes has been sent across the German lines.

(*k*) As early as the month of October, 1917, we were in possession of the necessary facilities to construct the Caproni, a powerful and successful heavy bombing plane, approved both by Italian and English aeronautical engineers.

Expert Italian engineers have been upon the ground since the month of January, yet the fact remains that we have up to date constructed only one experimental machine which is equipped with Liberty motors.

Nearly a year has elapsed since we might have begun work upon these machines and by this time have been in quantity production.

(*l*) The Handley-Page heavy bombing machine furnishes another example of delay. Plans were furnished the Signal Corps in the summer of 1917, but were not then availed of. Contracts for spare parts were not made until February, 1918. Deliveries of these spare parts did not begin until August, 1918. A sample plane ordered in March, 1918, was flown last July. Tests are not yet complete.

Causes for Disappointing Results

In the opinion of the committee the disappointing results above set forth are chiefly due to three causes:

I. That the airplane program was largely placed in the control of the great automobile and other manufacturers, who were ignorant of aeronautical problems.

II. These manufacturers undertook the impossible task of creating a motor which could be adapted to all classes of flying craft. It is not too much to say that our airplane program has been largely subordinate to the Liberty motor.

III. We failed at the beginning of the war to adopt the common-sense course of reproducing the most approved types of European machines in as great numbers as possible. This should have been carried on coincident with the production of the Liberty motor. This sound policy has very recently, but after a lamentable lapse of time, been adopted.

The mistakes and errors referred to would probably have been largely avoided if the aircraft program had been under the control of one man, assisted by skilled aeronautical engineers and practical fliers to design and test our machines, with production made subordinate to them.

Not a Wholesale Condemnation

This brief summary is not a wholesale condemnation of our aircraft program. Much has been accomplished. The committee is glad to report that while it believes there are yet many things to be remedied, nevertheless we are approaching a period when quantity production of planes may soon be hoped for.

The committee further reports in detail:

Beginning on May 29, your committee, instructed to inquire into the causes of delay in aircraft production, visited a number of training and testing fields and manufacturing plants in different sections of the country. It has since examined many witnesses, comprising manufacturers, fliers, officers, inspectors, and men more or less familiar with the subject and interested in the solution of its problems. The committee has not exhausted all sources of information, to do which would require the remainder of the session, but it received statements and heard testimony upon many features of the question. No attempt has been made to investigate charges of personal dishonesty or official corruption. That subject more properly belongs to the Department of Justice, which, under the direction of Hon. Charles E. Hughes, has been conducting an inquiry of its own regarding that and other phases of the subject.

In directing attention to conditions, both past and present, in the aircraft administration, your committee realizes that it is easier to criticize than to construct, and that due allowance should be made for mistakes of judgment, which are unavoidable in the organization of a new branch of the service, involving the establishment of an extensive industry. Our inquiry has been as impersonal as these conditions have permitted, and it is in the same spirit that this report is made.

The Aircraft Board

As originally composed, representatives of the automobile industry featured this organization, presumably due to the theory that aircraft engine and plane production were analogous pursuits. The latter was therefore submitted to the custody of men skilled in automobile production. A board thus equipped naturally depended upon motor-car engineers and manufacturers for the solution of aviation problems. But the analogy between the two pursuits virtually begins and ends with the fact that each uses a gas-explosive motor. Hence difficulties in design and production would tend to increase until such conditions were recognized. This fact must have been demonstrated to the board through its initial experiences, for Major Downey states that in the beginning the board wanted much authority with little responsibility.

"They wanted the Signal Corps to execute contracts and stand back of them, the board to be in an advisory capacity, and still control the situation."

Later, when—

"They saw the crash coming the board passed a resolution reaffirming the fact that they were only acting in an advisory capacity."

Organization under the Aircraft Board was unsystematic and ineffective. The chief officer of the Signal Corps was the nominal head, under whose ostensible supervision bureaus of engineering, equipment, supplies, lubrication, production, etc., were established, many of whose functions ill defined, conflicted with or overlapped each other. Contractors, inventors, material men, every one having business with this arm of the service and directed from one official to the other could not well transact their business and secure results with directness and efficiency. While this condition seems to be inseparable from official business routine in Washington, it featured largely in aviation from the start, materially hindering production on the one hand and diffusing responsibility therefor upon the other. Fairness, however, requires the statement that the identification by Congress of aircraft production and administration with the Signal Corps was unfortunate. The primary needs and importance of that corps as then defined were fully equal to the experience and efficiency of its commanding officer.

Aircraft Program

When Italy entered the war she made a careful study of aerial warfare upon the French front as then developed. Her engineers then selected the most efficient types of French flying planes and immediately put them into production under the supervision of skilled French artificers. Coincident with this policy she began the development of airplanes on her own account. Her armies were, therefore, rapidly equipped with an excellent service, afterwards supplemented by machines equally effective, but of Italian design and driven by Italian motors. By this means she avoided delay in production. She also promoted the development of her engineering genius by employing it under practical conditions upon the front with the best machines that France had produced.

Your committee does not understand why the Aircraft Board did not adopt this obviously essential policy. The Signal Corps dispatched a commission to the front, headed by Colonel Bolling, instructed to secure all needed information, evidently for that purpose. Col. V. E. Clark, the aeronautical engineer of the commission, made an elaborate report, having Colonel Bolling's approval, recommending the production of three English, two French and one Italian plane, but the report was not heeded. Designs for these and other types were placed by the allied governments, or by the inventors themselves, at the board's disposal, with assurances of expert aid to their vigorous construction.

An ostensible reason assigned for the board's inaction was the difficulty of translating metrical into linear measurements, and of obtaining quantity production of foreign motors. But the tardy acceptance and manufacture of some of the models and designs revealed the imaginary character of this objection. The board took some of the planes placed at its disposal and attempted with ill success to materially change them for American production. The general purpose of the changes seems to have been designed to adapt them to the Liberty motor, but this normal action should have been paralleled by their manufacture, both as to plane and engine, in strict accord with the plans as submitted.

Ultimately, and in the autumn of 1917, the board adopted one French and two English types of fighting planes to carry the Liberty engine. These were the Spad, the Bristol and the

De Haviland-4. Colonel Clark was instructed to redesign the Bristol upon the English model, retaining its wing load of about 7.1 pounds in a total weight of 2,937 pounds.

Hundreds of changes afterward made in this design by Signal Corps and production engineers without consulting Colonel Clark increased the wing load to about 9.2 pounds per foot, with an approximate weight of 3,700 pounds. Some of these changes were required by the increased strain of the heavier and stronger motor upon the structure. The machine was finally put into production and then abandoned after the test of July last, and after an expenditure of more than $6,500,000 and the loss of several valuable lives.

The overload placed too great a strain upon the wings, and this, with bad construction, compelled the board to stop production. The money loss may be partly recovered by salvage. The loss of life and of months of precious time through the need of substituting another type of plane for the Bristol and then producing it are matters of far more serious concern.

In September, 1917, the Signal Corps contracted with the Curtiss Company for 3,000 one-seater Spad planes. This is an excellent French biplane, then and now in use on the front. In October the contract was canceled, the reason given therefor being that it was done at the direction of General Pershing. Inasmuch, however, as General Pershing's cablegram concerning the subject bears the date of December 14 following, we must accept the statement of the Curtiss Company's officials that the board canceled the contract because it desired to equip the plane only with the Liberty eight-cylinder motor, which was found impracticable. The Liberty-8 was about that time discarded.

The plane was too light for the Liberty engine, so its production was suspended. The French use the Hispano-Suiza motor with this plane, and the Curtiss people assure us that their contract would long ago have been completed and the planes in the service at the front had the manufacturers been permitted to proceed with production. No attempt was thereafter made to manufacture single-seater fighters, ostensibly because of the Pershing cablegram, until May last, when Mr. Ryan placed an order with the same company for 1,000 SE-5 planes. This is substantially the English equivalent of the Spad, and will probably be in production during the coming autumn. It is manifest that if the manufacture of the SE-5 is proper at this time, then the discontinuance of the manufacture of the Spad was a mistake, regardless of who is responsible therefor.

The plans for the Caproni and the Handley Page bombing machines were available to the board soon after our entry into the war.

Early in the summer of 1917 the Standard Aircraft Company was instructed to hold their plant at Elizabeth, N. J., in readiness to build Caproni planes.

About September 15, a verbal contract was made with the Curtiss Company, formally confirmed on October 8, 1917, to build 500 Caproni planes. This contract was never carried out, because no information was furnished to the Curtiss Company, although they repeatedly endeavored to secure the same. Afterward it was canceled, and contract for the Bristol fighter was substituted.

As early as October, 1917, at an international conference in Paris concerning a general aviation program, the Italian inventor, Caproni, was summoned to meet Colonel Bolling, one of the heads of the aviation section in Paris. An arrangement was ultimately made by which Captain D'Annunzio and a force of workmen and engineers were to be brought to America to produce in American plants Caproni machines. Captain D'Annunzio and nineteen of the best men of the Italian factory arrived in the United States on January 17.

In January, 1918, the Standard Company was given a verbal order for 1,000 Capronis, 50 to be assembled and 950 to be sent overseas knocked down. Drawings were prepared, but no official order was given for the machines,

On January 25 Captain D'Annunzio and his men came to the plant, began work on a handmade machine. A witness describing the transaction states that—

"They (the airplane authorities), in February, began to back and fill on whether they were going to build Capronis in quantity, and by March 2 it was practically settled that they would not build Capronis in this country at all, except the ones we were working on and two or three for experimental purposes. As a result of that we took the Handley-Page as a substitute."

Captain D'Annunzio states that he had expected upon his arrival in this country that everything would be ready. "They were wiring and cabling Italy, asking for the engineers of the Caproni plant. I requested General Tozzi, who is head of the Purchase Mission, in Washington, to help me clear up the matter. So we provoked a lot of meetings between myself, Colonel Deeds and some others officers. * * * It was just the same as before, because no decisions were reached. * * * I found they were undecided as to whether they should make that machine, although demonstrations had been given before the European military mission," etc.

Finally Captain D'Annunzio was authorized to build the first experimental machine for American engineers. That machine was finished and flown on July 7. In the meantime, and about April 12, the Fisher Body Company obtained an oral contract for 250 Capronis, which was later canceled. Again, about May 18, 1918, the Curtiss Aeroplane and Motor Corp. was given an order for 500 Capronis, and on the same day the Fisher Body Company was given an order for 500 Capronis. It is understood, however, that nothing will be done to carry out this order until the experimental machine has been tested out. This precaution is proper.

During the interval of delay both of the Italian pilots who came to this country were killed in other machines, and the Caproni program is now awaiting the arrival of Italian pilots and the testing of the experimental machine.

The Handley-Page

Plans for the Handley-Page machine were supplied to the Signal Corps in the summer of 1917 by the owner, with full permission to use them. Its engineers made a number of changes in them, beyond which nothing was done with them. Hence, the representative of the owners in the early winter demanded their return. They were delivered to him as changed.

In February last contracts for 1,000 sets of parts, afterward reduced to 500 sets of parts, were made with various contractors, to be assembled in Great Britain for the use of the American Army. From 60 to 90 days are required for the assembly of a Handley-Page machine. Twenty of these have been embarked, and we are informed that they will continue to go in constantly increasing quantity, reaching 140 for the month of February. Had these contracts been let last October they could have been completed and delivered by the 1st of July.

One sample machine constructed by the Standard Aircraft Corp. was completed and given its initial flying test on July 6 last. If further tests prove satisfactory the design will go into quantity production. Had the machine been ordered last summer it should be in quantity production now.

The production of training planes has been fairly adequate. One type, the Standard, of which there were 1,200, has recently been discarded because the Hall-Scott engine which drives it has proven unsatisfactory, but there is no reason to apprehend that training plane production will fall below the requirements of the service. The designers and manufacturers of this plane insisted that with a good engine it is all right, and this insistence will be tested. If successful they can be made available hereafter. But General Kenly and his assistants found them highly dangerous because of the motor and ordered their retirement. The machines cost the Government about $6,000,000.

The De Haviland-4

The De Haviland-4 is the only so-called fighting plane now in actual production. Outstanding contracts call for 8,500 of them. They are being manufactured by the Dayton-Wright and the Fisher Body companies, with smaller contracts to the Standard and one or two other producers. On August 1 a total of about 1,000 of these had been delivered, all but a few of which had been turned out by the Dayton-Wright concern.

The first plane of this type was embarked for France during the latter part of February of this year, but never reached port. Up to July 1, 286 had been shipped abroad, of which sixty-seven had reached headquarters in France. On August 1 601 had been embarked. A number of them were delivered to General Pershing's headquarters in June, and upon inspection were found to contain many defects, some of which were serious, others of less importance. Under date of June 26, General Pershing cabled the War Department enumerating many defects and stating explicitly that the machines could

not be used until some of them were corrected. Also that all planes of this class should be thoroughly tested and inspected before being shipped to him. This obvious requirement General Kenly had insisted upon observing, but sent them over in the instance considered without doing so because of an overseas order requiring it.

Machines Dangerous

Some of the defects enumerated in this report, in the opinion of every expert flyer who has been examined by the committee, rendered the machines more than ordinarily dangerous. Their opinions differed as to whether or not corrections can be made to make the machines safe, but the assertion that the plane is very unsafe in the condition in which it has been up to this time delivered from the factory was practically unanimous. Deliveries of the machine continued notwithstanding, and many were sent to France in precisely the condition complained of in General Pershing's cable. The explanation offered for continuing delivery of these defective planes is that the corrections could be made overseas, and a force of American officers and mechanics under command of Lieutenant Colonel Hall was dispatched to France about the middle of July with orders to make them. Your committee is of opinion that the planes should never have been permitted to leave the factory in their defective condition, and the fact that they were permitted to go shows either a lack of appreciation of the situation, a disregard for it, or a very poor system of inspection. On August 2 an order was issued to all the factories directing that no more of them be delivered until the corrections required were made. We are informed that production under these new conditions is about to be resumed.

In July 155 of these planes were delivered to the Navy, about fifty of which were shipped abroad and approximately one hundred crated and delivered at the seaboard for shipment. At this stage four of them selected from the lot were sent to the Navy testing field at Miami, Fla. A test and inspection there revealed the same defects that were reported by General Pershing and some others. The commandant, Captain McCaughtry, immediately reported this fact to the Navy Department, with the result that a cable was sent to Admiral Sims apprising him of the defective condition of those previously sent, while the one hundred in crates at the port of embarkation were rejected and returned to the Aircraft Board.

Engineers Without Aviation Experience

Forty De Haviland-4's sent to a Long Island field about this time and tested out in the vicinity of New York were pronounced structurally weak and defective. With the production of the De Haviland-4 it has been the same story of changes. Many of these have been made in the plane since the board determined upon its manufacture. Some were unimportant, some extremely so; many of them undoubtedly necessary to its adaptation to the Liberty motor. But they have been made for the most part by automobile and mechanical engineers, having little or no experience in aviation engineering.

On the 28th, 29th and 30th of July three squadrons of eighteen machines each, fifty-four in all, having been overhauled by American and French mechanics at an American aviation base behind the French lines, were delivered to the front under their own power. These planes are said to have received the approval of Captain de Haviland after a careful inspection. Assuming this to be true, it indicates that the machines sent over have been carefully inspected and the defects remedied. On August 7 one squadron of these, comprising eighteen machines, under command of General Foulois, made an expedition across the German lines and returned in safety to their base. This marks the date of the use of the first American-built plane over the enemy's lines. The committee has no information regarding the character of their performance.

The character of the evidence concerning this machine, ranging from qualified approval to severest condemnation, shows that the De Haviland-4 is chiefly available for observation or reconnaissance purposes. That the War Department and the Aircraft Board share this view is best evidenced by the fact that it is to be replaced by a machine of later design as speedily as may be possible without complete suspension of production.

With the exception of the S. E. 5 and the Handley-Page, in parts, no other type of fighting plane can be produced in quantity before 1919.

The U. S. D. 9 plane is a redesign of the British DH-9, being a great improvement on the DH-4. But the U. S. D. 9 has not yet fully responded to the tests of the military bureau and will go into production only when it does so. The U. S. D. 9A, another and later design, now under test, promises to be a satisfactory machine. If the promise is fulfilled by the tests, the design will be adopted and substituted for the De Haviland-4.

Deliveries of Foreign Machines

Recognizing the fact that the United States would not produce planes in quantities early in the war, the board contracted with the English and French early in 1917 for a supply of fighting planes. Of these, 2,114, according to the latest testimony we were able to receive, have been from time to time delivered. This enabled us to maintain thirteen squadrons of eighteen fliers each on the front, a force which is wholly inadequate to meet requirements of modern warfare. It should also be stated that as our troops are moving to France in great numbers, the disparity may increase until we get into quantity production. It is proper to call attention to the fact that at an investigation of the War Department by the Military Committee, held in January and February, 1918, the committee was assured that the French could and would furnish all the combat planes we needed, provided we would send them the raw material, and that this material was being furnished. This assurance was given when the committee showed anxiety at the continued delay in the shipping of planes.

In January General Squier and Colonel Deeds testified to this fact and Secretary Baker gave similar assurance to the committee. The facts, however, are as shown by the testimony of General Kenly, given on July 20, that the plan failed for two reasons. We quote his testimony:

"The French contract practically fell down, as you know. * * * It was due to what I consider two reasons. In the first place, the contracts with the French were dependent upon the sending of raw material that was to be furnished by us, and we did not live up to our agreement. * * * In the second place, the increase in German activities in the air caused a change of program in French aviation construction. * * * The French contracts fell down, so that we became more or less dependent upon what could be furnished on this side."

Besides this, many of the machines our men are now forced to use in France are unsatisfactory, but not more so than those used by the French themselves. An Army officer recently at the front testified that the American troops are using many antiquated machines purchased from the French that were discarded by them a year and a half ago. They are using the Sopwith, 1½ strutter, which has been declared unsafe by the French and British for observation work. They are using the A. R., equipped with a Renault-220, which has a ceiling of only 10,000 feet. They use a Spad two-seater, which is unreliable and unsatisfactory. They were using a few French Brequet machines and the Salmson, which is a French machine. It is therefore reassuring to reflect that all commands are unified in France, with all lines of the service under a common protection.

The Liberty Engine

The Liberty 12-cylinder engine is an excellent one for the heavier planes and certain other purposes. Its weight of 825 lb. and its 400 hp. makes it too heavy and too powerful for the lighter types. It is not yet perfect, but it is improving under repeated tests and experiments, which disclose defects for elimination and suggest changes and readjustment of its parts. It is now in quantity production, more than 4,000 having been delivered, and is approved by our allies, who are anxious to obtain more of them than we can at present supply.

In the development of this motor the Aircraft Board has performed an important task, for which due credit should be given. But the announcement that it had been evolved in a few days was unfounded, and the notion which was encouraged that it could be used for planes of all sizes and character was largely responsible for delays to our plane program.

Foreign Engines

Motor production has proved to be a formidable task, magnified in some degree by the reluctance of the designers to

promptly accept and act upon suggestions of imperfections from competent engineers and critics and fliers and make changes in conformity with them.

The manufacture of the best foreign motors, among which are the Rolls-Royce, Hispano-Suiza, and Fiat, contemporaneously with the development of an American engine would have been the sounder policy. That it was partially adopted later confirms this conclusion. We are doing what should have been done a year ago and are producing the 150 and 180-horsepower Hispano-Suiza motor in quantity. Deliveries of the Le Rhone, Bugatti, the 300-horsepower Hispano-Suiza will follow.

American concerns are making the Rolls-Royce motor for the British Government and should long since have been making them for ours. The smaller types of Hispano-Suiza are serviceable for the lighter and faster planes. In view of these conditions, the apprehension of a year ago that we could not produce foreign motors in quantity because of their metrical measurements and intricacies of construction, requiring manual instead of machine work, which we did not possess, becomes untenable.

No American Designed Airplanes

No fighting plane of American or other design has been built around the Liberty engine, although it is an axiom in aeronautics that planes must be adapted to motors. The Aircraft Board authorized some attempts at this all-important work, one by Captain Le Pere and one by Colonel Clark, the first of which is being tested and developed by the board, with good prospects of success. This should have been done before, as the type must be made effective before the best performance of the Liberty motor can be secured. A Curtiss design also gives promise of satisfactory results in the near future. The motor can be used in some other models with good results, but until a Liberty plane is successfully built around a Liberty motor by competent aeronautic engineers and thoroughly tested out our air program will not be complete.

Inspection

The Signal Corps inspection system has paralleled that of the producers. In some instances it has functioned badly, with the result that defective material has at times been accepted and material condemned and reported to chief inspectors has found its way back to the producer. In some factories the finished product has been accepted, although not up to requirements. Generally speaking, the production and inspection systems of the manufacturers seem to be more co-operative than competitive. We have found no collusion between the official and the private inspector, but the inspection in the past has been bad. The faults of the system are in part due to the incompetency of the inspectors. We are informed that the system has undergone, and is now undergoing, a radical transformation, and is being remedied as rapidly as skilled and efficient operators can be secured.

Training and Testing Fields

The training fields are each designed for 600 enlisted men, 300 cadets, and seventy-two officers, a total of 972 men, which, owing to the exigencies of the service, have at times been exceeded. This arrangement requires a total of fifty-four structures of all sorts for each standard field. In addition to these, there are repair and supply depots, balloon schools, experimental stations, radio laboratories, warehouses, quarantine camps, temporary barracks, photograph schools, etc.

Up to May 25 last there were thirty-one fields, including balloon schools and experimental stations, and thirty-seven miscellaneous projects comprised in the above recital, not including the training schools at various State and other universities, nor projects recommended but not yet approved by the War Department. Their estimated cost is $52,511,134, of which $39,356,407 have been expended, exclusive of a field at Miami, Fla., established by Col. E. A. Deeds, a member of the board, on his own responsibility (and without the knowledge or sanction of the head of the equipment division having charge of the work), and a night flying route from Dayton, Ohio, to Rantoul, Ill., by way of Indianapolis. The cost of these extra projects was over $400,000. This night flying route was used for the first time on the night of August 12 between Dayton and Indianapolis, and was pronounced satisfactory by Gen. Charles E. Lee and Capt. J. Fitzmorris, of the British air service, and the aviators who made the trip.

Mr. Potter's Work Approved

The Equipment Division had some difficulty in securing material for construction prior to the advent of Mr. W. C. Potter, now Assistant Director of the Production Board, since which time there has been much improvement.

The contractors for the work at Langley Field and the fields at Dayton were not satisfactory. Upon the whole, the work of construction proceeded fairly well and the structures on most of the fields have been completed.

Langley Field, near Newport News, Va., consisting of 1,650 acres, was selected prior to our entry into the war for a training and experimental field. The estimated cost of its needed buildings, not yet completed, is $3,664,050, of which $2,305,697 have been expended. It seems to have been wisely chosen and well fitted for testing and experimental work. Nevertheless, it was practically abandoned last year for that class of work, and McCook Field, at Dayton, Ohio, consisting of but 200 acres, and practically inclosed by river, trees, and telephone and telegraph wires, was selected instead and leased at an annual rental of $12,500. The reason assigned to the committee for this change was the lack of transportation facilities at Langley, although a spur connecting it with nearby railway systems had been constructed by the Government for its express accommodation prior to the transfer. The insufficiency of this reason is emphasized by the fact that about the same time the board selected the Wilbur Wright training field, near Dayton, requiring the construction of a trolley line by the Government, at a cost of $175,000, which is its only line of transportation. The field is now being used by the Bureau of Aeronautics for its military testing plant. McCook Field is not only too small for satisfactory experimental flying, but its environment is unfavorable to its use for that purpose. The board has, however, equipped it with structures costing $920,100.

Adjoining the Wilbur Wright Field is a large warehouse, built at a cost of some $500,000. In this warehouse are stored great quantities of supplies, many of which, like machine guns, radio batteries, photographic accessories, etc., are manufactured in the East. To send them hundreds of miles west for storage, reshipping them over the same route back to the seaboard when needed for overseas uses, is waste. It needlessly adds to railway congestion and should be corrected.

Wilbur Wright Field

Your committee visited but a few of the training fields, of which Wilbur Wright Field, above referred to, was one. It comprises 2,200 acres and belongs to the Dayton Conservancy Association, and is designed as a part of the bed of a great reservoir to hold back the flood waters of Mad River. Much of it is low and swampy, either on a level with or slightly above the normal level of the stream flow. Any considerable rainfall floods a great portion of it, and a rain of 36 hours last March caused an overflow of nearly 2 feet above the floors of the hangars, thus seriously threatening the planes with damage and suspending training completely. A drainage system, since installed, is said to have improved this condition, but your committee is informed that the Signal Corps was advised by competent authority against locating a field upon these premises because of its low and marshy character, and the judgment of the officers and fliers at the field and familiar with the ground was a unit against its adaptability. An excellent stretch of ground within four miles of this field, traversed by railway and high above the river level, admirably drained by nature, was available to the board when Wilbur Wright Field was selected.

Buildings Must Be Removed

The large sums expended upon the Dayton-Wright Field, amounting to $2,878,699, and requiring an ultimate total of $3,097,777 and its use for testing purposes, probably demands its present retention if the drainage system referred to shall prove fairly effective. But when the dam is completed—the reservoir is to be filled—the buildings must be removed or they will otherwise be submerged.

More recently the board, desiring an additional field near Dayton, was offered an acreage adjoining the Dayton-Wright airplane factory on the east. Inasmuch, however, as insistence was made that the lease be executed to the Dayton-Wright Company, as lessee for the use of the board, the rental to be made an item in the cost of airplane production, the representatives of the board very properly declined the suggestion,

and the projection is still incomplete. We feel obliged to note in this connection that shortly before negotiations for the McCook and the new field, Col. E. A. Deeds, a member of the Aircraft Board, was the owner of the first and a part owner in the second. He sold and transferred them to interests with which he had been identified and which now own them.

Contracts for Planes, Motors, and Accessories

At the outbreak of the war but few concerns were engaged in airplane and motor construction; but there were concerns devoted to other pursuits and potentially capable of producing both in quantity if encouraged to do so. The need for planes in volume, and as rapidly as possible, prompted Congress to make the largest single appropriation for the Signal Corps which, up to that time, had ever been made. Since then our engine-producing capacity has been fairly enlisted, while that of plane production has not been properly encouraged. A number of plane manufacturers, like the Wittemann-Lewis Company of New Jersey, and in the business years prior to the outbreak of the war, have been unable to obtain contracts; while a number of concerns like the Dayton-Wright Company and the Standard Company have been practically organized since the war, and the former was given enormous contracts before its factories were completed.

Companies assured of capital and factory space have been denied contracts because they were not going concerns, while other companies in similar condition have received contracts, notwithstanding their present lack of producing equipment. No one official controlled or supervised the making of agreements or their execution. Beginning and ending with the Aircraft Board, the head of production, the director of supplies, the head of the contract section, and perhaps other links made up the chain of procedure. Adopting models of proved efficiency and then putting all responsible producers at work upon them would, in the opinion of your committee, have greatly expedited, as it would have guaranteed, the performance of the aircraft program.

To aid in the construction of the Dayton-Wright plant and the Elmwood plant of the Curtiss Company, the board made generous advances of money, and to them was given the task of making and supplying other contractors with plans, designs, blue prints, and specifications for the accepted types of machines, exclusive of bombing planes. This gave these concerns great advantage over their competitors, which thus became dependent upon them for material without which the work of production could not begin, and when begun was subject to suspension and delay with changes in construction and design. Moreover, the Curtiss Company exacted a fee for copies of plans, etc., of one per cent upon the contract price from other contractors, which, although added to the cost of production, was paid to the Curtiss Company, adding a considerable aggregate sum to its revenues.

The number and amount of contracts for planes and motors assigned to concerns at Dayton and Detroit and the number and character of aviation fields at Dayton could not fail to attract the attention of your committee. Due to her vast automobile industry, Detroit doubtless possessed greater facilities for gas engine production than any other American community, and the Fisher Body Co. was well equipped for the manufacture of planes in quantity. A generous recognition for these facts was therefore inevitable.

But Dayton possessed no such advantages. Her manufacturing interests were for the most part in other directions. Industrially considered, the concentration of the greater part of the new pursuits in these two cities may perhaps be justified, but the committee is forced to the conclusion that the personnel of the Aviation Board, from its formation to its reconstruction, explains the fact.

Automobile Control

The civilian personnel of the board and their more prominent subordinates were composed of gentlemen, a very considerable number of whom lived in these cities and before or at the time of entering the Government service were leaders in and identified with the industrial development of their respective communities. The divestiture of their interests by transfer to others was a laudable though essential step toward qualifying them to public service, but the granting of major contracts to old associates, the transfer of the experimental station from Langley to Dayton, and installing it upon an inadequate tract, quite recently the property of a member of the board, the tender and qualified acceptance of a second field, formerly owned in part by the same member, the selection of the Wilbur Wright Field, physically and geographically unsuited for the purpose, and the giving of huge contracts for airplanes to a corporation created since the war began, of which he was one of the first officers, and owned exclusively by his former partners and business associates, have provoked, and we think justly, much of the public comment which made the investigation imperative and much of the resentment of less favored manufacturers in other localities. It is also a distinct argument for those who assume to fear and who assert that aviation, through the board, is to be made the subject of ultimate automobile control. This feature of the subject is, as heretofore stated, under full investigation by the Department of Justice.

Cross-License Requirement

Although this subject has been referred to a special subcommittee for investigation, it has constantly obtruded itself upon our attention, hence we cannot avoid referring to it.

The National Advisory Committee of Aeronautics, confronted with the necessity of satisfying the claims of patentees and avoiding possible delays threatened by conflicting patent rights, determined upon mature consideration to settle these difficulties through the agency of a Manufacturers' Aircraft Corporation, to be composed of those engaged in the industry and empowered to license all aircraft contractors, who should pay a royalty to the company upon all planes and parts to be constructed and to assign to the company for the common use all patents or applications therefor owned or controlled by the licensees. The bulk of these royalties was to be paid to the Curtiss and the Wright-Martin companies as compensation for the use of certain patents until each had received $2,000,000. These were to be charged against cost of production and paid by the Government. The agreement was sanctioned by the Department of Justice and approved by the Secretaries of War and the Navy.

The committee has not heard a word in approval of it. It is condemned by every airplane manufacturer outside of the immediate beneficiaries. Those executing the license agreements have done so under protest because the Aircraft Board recommended or required it.

Criticisms of it are numerous, the most serious of them being that it subjects manufacturers to onerous requirements by its beneficiaries, such as assessments for the use of plans and specifications, the purchase of the material and accessories from favored houses, the assignment and surrender of valuable patents and patentable devices of the Aircraft Association upon terms prescribed by itself, the discouragement of invention, and the inevitable control of the aircraft industry by that association or by some other interest through its agency. Your committee sympathizes with many of these sentiments, and notwithstanding the Aircraft Production Board as now officered no longer requires or recommends the execution of the agreements by contractors, we believe the arrangement should be abrogated. We regard it as vicious and as designed to reap large profits by taking advantage of the necessities of the Government. The basic patentees should, of course, if the patents are valid, be compensated, but this should be done by the Government directly whenever the courts finally determine who the owners are and the patents should then be made free to all manufacturers.

New Patents

New patents of meritorious character should be similarly acquired by the Government as they appear. Such a course would stimulate invention and promote the development of an art which is still in its cradle.

This is not a new departure but rather a reversion to an original policy, for Congress in 1917 appropriated $1,000,000 for the purchase of aircraft patents, which sum is still available, and if insufficient for the purpose it can be easily increased. The Government should never be made the victim of a patent monopoly which it generously created for the sole protection of the inventor against infringement by persons and corporations.

Difficulties of Aircraft Production

Much can be said in extenuation of the disappointments encountered in aircraft production. The industry is new and highly technical. Mechanics skilled in the art were few when the war began, and of aviation engineers there were scarcely any. Production capacity was undeveloped, and even planes for training were not immediately obtainable. Up to Jan-

uary, 1917, only 118 airplanes of all types had been delivered to the Army, sixty-four of which were made in 1916, and there was no aircraft organization either in the Signal Corps or out of it. The Bolling Commission was not sent to Europe until June, and its report was not received until September. But for the glowing forecast and optimistic announcements which the board and others made to the public from time to time regarding its actual and prospective performance, and the certainty of speedy and unlimited production, public disappointment would not have been so pronounced nor public resentment so widespread. Great Britain in 1915 and 1916 experienced delays, miscarriages, and expenditures. Instead of profiting by her experiences the board incurred similar ones and accentuated them by representations and assurances which were not warranted by the actual facts.

The order of the President creating a Military Bureau of Aeronautics and a Director of Aircraft Production and the appointment of General Kenly and Mr. Ryan as the heads of the two divisions is an improvement upon the previous situation, and a number of the conditions we have criticized have been or are in the process of being corrected and better methods instituted. For example, a single board of engineers formed by combining the technical and production engineering sections and headed by a chief selected by Mr. Ryan, with the approval of General Kenly, has been established; one testing board under the command of a single officer has succeeded the double system formerly doing the work. The Military Bureau, under agreement with the director, after thorough experiment by actual fliers and aeronautic engineers, now determines the character of machine to be produced, and the business of the director is to produce it.

Recommendations

1. The inspection of the finished product and other material is now the work of General Kenly's division and is to be done by thoroughly competent officers. Work not satisfactory to General Kenly or not up to the requirements of his Bureau is rejected. Cooperation for the common end has been, and we hope will be, observed by the heads of the two divisions and required from their subordinates. The loose ends of the former organization have been gathered up as rapidly as possible, and the results of the improved conditions are already apparent in some directions. But the system is still subject to the criticism that it is dual in character, which is unsatisfactory, since it may at any time lead to differences and to division of responsibility. We are constrained, therefore, to renew the committee's recommendation of last April, sustained by the opinion of every man whose views were consulted by us, that the whole subject should be under the control of one man. Our present organization is faulty because divided into two parts with a man of strong will and opinion at the head of each division. While these two divisions are correlated, they may not be permanently coordinated. Your committee therefore believes that the importance and magnitude of aviation as a permanent branch of our military organization requires one directing and responsible head both for its efficiency and speedy development. Its classification with the Army and Navy as a distinct arm of the service is essential to this end.

Of comparative insignificance at the outbreak of hostilities in 1914, aviation has become indispensable in modern warfare. Without aircraft no army can any longer hope to triumph or, indeed, to escape inevitable defeat. Without aircraft the most powerful navy must in these days remain upon the defensive. The aircraft force of Great Britain and France each outnumbered the Regular Army of the United States when we declared war, and ours should soon be as large as theirs. It is a distinct arm of the service. Great Britain and France, recognizing its supreme importance and the need of its swift expansion, last year each covered it into a department of its own, whose head, as minister of the air, ranks as an officer of the cabinet, who is held responsible for efficiency of production and manufacture and an efficient force of aerial fighters. We should do likewise—create a department of aviation, under the control and supervision of a secretary, and ranking with those of the Army and the Navy. We would thus place power and responsibility in the hands of a single man, organize a service not alone for this war, but for all time, and establish for the forces of the air the same policy of administration that has so long governed those of the land and of the seas.

The cost of equipment and maintenance is rapidly approaching that of the Navy, while training for aviation is as distinct and as technical as that for West Point and Annapolis.

Air Department Recommended

The creation of the department of the air would unify the service, thus removing all friction between the Army and Navy divisions of the service by subjecting both to the control of a common head. Differences between them under present conditions are unavoidable, and, while more disagreeable than serious so far, they will arise from time to time, tending to seriously disturb the service, besides interfering with production.

2. A commission of engineers and pilots for observation at the front, formed in relays and reporting in person to the department at frequent intervals, is also imperatively demanded. The betterment of the air service through the exigencies of actual warfare is rapid and important. They should be accurately and promptly reported in detail to the home office, and this can be efficiently done in no other manner. Similar conditions have long been maintained by our allies, whose policy in this regard we will do well to adopt.

3. But your committee feels that the prime need of the hour is machines in continuing quantity, and the production of them should be accelerated by enlisting the constructive activities of all responsible concerns engaged or which can be engaged in the business to full capacity. We cannot, while the war lasts, have too many effective planes. Supremacy of the air means a speedy triumph. Indeed, it may prove our only certain weapon of success. We have hundreds of trained pilots waiting for planes, whose services must be postponed for their production.

Planes to be useful must have motors. These, too, should be in production in every factory that can and will turn them out, due allowance being, of course, made for other equally insistent requirements for ordance, ships, and the like. If this is done, the results for 1919 will then compensate somewhat for the disappointments of the current year.

4. The rapid development during the war of the airplane and its effective use as an important arm of the military, makes it imperative that America give greater attention to the perfection and production of aircraft. This should be done not only as a war measure but as a commercial and industrial necessity.

The importance of a powerful air force and an abundance of heavy artillery cannot be overstated in bringing the war to a speedy and successful conclusion. With our vast resources in raw material and our facilities for manufacture we can, by the adoption of a broad program and with the assistance of our allies, obtain the complete supremacy of the air.

Without hesitation or delay we must give attention to this expansion of our aircraft policy. The inventive and productive genius and energy of America must be devoted to the creation and improvement of new types of aircraft and engines. Our present program must be greatly enlarged. The United States should establish at Government expense college and university courses in aerodynamics and mechanical engineering, in addition to courses for training fliers.

While quantity production is essential to the complete equipment of our armed forces, quality should not be sacrificed to quantity. The airplane requires the highest degree of skill in workmanship and the very best kind of materials.

The airplane is a product of American genius, but the credit for its development largely belongs to other nations. America should meet this challenge by bringing the airplane to still greater perfection.

Inventors Need Encouragement

5. The inventive genius of the nation should be encouraged in the most effective way. A Bureau of Inventions, recently established by the War Department, is a step in the right direction. A persistent complaint, doubtless in a large degree due to the disappointment of men whose devices have not been pronounced practicable, is that under the administration of the old board scant consideration has been given to new devices and suggestions. This seems principally to have resulted from the absence of any well-defined individual agency having full authority to deal with the subject. One man, the designer of a model for a dirigle with a car integral with the Blimp, began with the Advisory Committee and was

passed on from one officer to another until he finally completed the circle and was referred back to the committee which started him on his journey. About six months were consumed in making the circuit and nothing was accomplished. A plane designer encountered a similar experience, with the added one that his plane was crushed to pieces in a sand test which was declared satisfactory by those who made it but wholly unsatisfactory by those empowered to make final decisions. Many, perhaps most, of the so-called inventions brought to the notice of the authorities in times like this are of no importance. But if the germ of something new and useful can be detected in one of a multitude of models, the time and energy expended in discovering it will redound to the benefit of the nation.

6. Ample protection should be extended by the Patent Office to applicants for patents for inventions relating to the public welfare and defense. This is demanded not so much for the inventor as for the nation. Authority for this now exists, but it seems to be exercised at times and disregarded at others. Additional legislation may be necessary to make this precaution effective, but in the meantime a suggestion from the Production Board to the Commissioner of Patents regarding applications for inventions relating to aircraft would doubtless shield the application from all publicity, thus assuring its indemnity against disclosure to enemy interests.

7. The margin of profit on some contracts, particularly for motor production, is altogether too high. According to the estimates of the accounting division they appear to be for the Liberty motor at one of the plants, 33.6 per cent; for Liberty engine aluminum pistons, 285 per cent on capital invested; for the Le Rhone, 92.8 per cent on cost of production; and on the DH-4 plane about 50 per cent. This is largely due to the primary unfamiliarity of officials with the cost of rapid manufacture of novel products in great and urgent demand.

The high cost to the Government having been now demonstrated we feel sure that future contracts will result in great saving to the Government.

8. Planes and engines rejected because of defective construction or materials not furnished by the Government direct should be at the cost of the producer. Existing agreements require payments from the Government for everything delivered, presumably because they have passed official inspection. But when producers are required under their agreements to bear the expenses of an inferior product, on the perfection of which human life is absolutely dependent, their own inspection will be of the best and good workmanship will inevitably result.

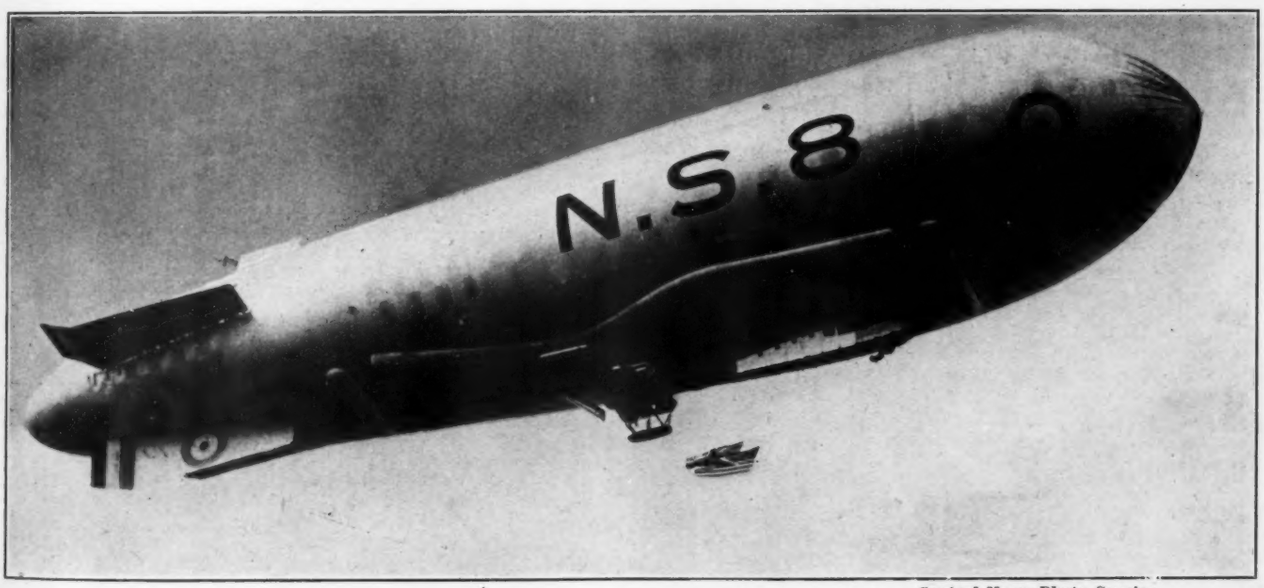
9. Your committee in inspecting the aircraft plants have noticed the great danger of destruction by fire, owing to hazardous processes of manufacture, hasty construction, lack of automatic sprinkler and other fire protection.

The burning of any of these factories, in whole or in part, at this time would be a catastrophe, for it would greatly cripple the aircraft program.

We urgently recommend that the requirements of the Fire Prevention Bureau of the National Council of Defense, composed of fire insurance experts, for better fire protection in these factories be made immediately compulsory by the director of Aircraft Production, and that a stipulation be inserted in future contracts compelling a compliance with such recommendations.

Supplementing its public report of the aircraft situation, it has been announced that the Senate sub-Committee will make a second secret report to Secretary of War Baker.

British Airship Development



Central News Photo Service

The accompanying illustration, representing a British naval airship of the N. S. (North Sea) class, furnishes conclusive evidence to the considerable progress achieved by British designers in the development of large non-rigid airships. While this vessel is apparently of the Astra-Torres type, characterized by an internal rigging system which is maintained in tension by the tautness of the hull, that is, by the internal pressure of the gas, it embodies several notable improvements on the pre-war airships of this type.

Whereas in the latter the car was slung under the hull by exposed rigging guys, and contained the power plant, the N.S.8 has apparently a closely adherent, well streamlined car, while the power plant is mounted on an independent structure rigged well abaft of the car. The air intake pipe leading from the power plant to the air manifold and the distributing pipes to the forward and after ballonnets are clearly visible in this illustration, as are the bumping bag fitted to the nose of the car and the twin-oats arranged underneath the engine structure. The symmetrical shape of the tail planes is also worth noticing.

The close rigging of the car to the hull, which is carried out in a fashion reminiscent of Forlanini practice, besides reducing overall height and thus facilitating housing, has obviously the advantage of greatly reducing parasite resistance, so that the performance of the N.S.8 ought to be exceptionally good for a non-rigid airship. On the other hand, the mounting of the power plant in the immediate neighborhood of the hull suggests that British airship designers have little fear of conflagration from this source, which is probably insured against by highly gas-tight fabric and efficient exhaust collectors.

Some Outstanding Problems in Aeronautics*

By Dr. W. F. Durand

Chairman of the U. S. Advisory Committee for Aeronautics

Maintenance of Power at Altitude

We come now to a problem of the very highest present and future importance, that of maintaining the power of the engine at high altitude.

The situation as it develops in the case of an airplane mounting to higher and higher levels in the atmosphere is readily appreciated with a moment's thought.

The power of the engine arises from the combustion of vaporized hydrocarbon fuel. The power per cycle for a given cylinder will, therefore, to a first approximation, and assuming a sensibly constant efficiency of thermodynamic transformation, vary directly with the weight of the fuel which can be burned per cycle. But this in turn depends upon, and is conditioned by, the amount of oxygen which can be drawn into the cylinder per intake stroke of the cycle. But the oxygen is brought in as one of the constituents of the atmosphere, and hence the amount of oxygen available per intake stroke will depend upon, and be directly proportioned to, the amount of air which can be drawn in. But in terms of volume, just a cylinder full or more exactly, just the volume represented by the piston displacement in moving from one end of the stroke to the other, can be brought in. Hence we may at least depend on what we may term a cylinder volume of air, no matter where we are. But just here arises the trouble. The actual weight of air depends conjointly on the volume and on the density, and unfortunately for the aeronautical engine at least, the density of the atmosphere decreases steadily with altitude, so that at 15,000 feet, for example, the density is only about 60 per cent of the normal density at the earth's surface. It is clear, then, that an aeronautical engine, other things equal, will draw in, per intake stroke, only about 60 per cent of the weight of air at this altitude as compared with the indraft at the earth's surface. Hence it will be able to burn only 60 per cent of the fuel and with equal efficiency will develop only 60 per cent of the power.

But here we must stop for a moment and inquire as to the effect of such reduction of power on the speed of the airplane. We know that, other things equal, the resistance of an airplane to propulsion through the air at uniform speed varies directly with the density of the medium. Hence with the same speed as when near the surface of the earth and at the same altitude and angle of attack, the airplane at 15,000 feet elevation would experience only 60 per cent of the resistance, require 60 per cent of the thrust, and, at constant revolutions of the propeller, 60 per cent of the power from the engine. It appears, therefore, at first sight as though we had lost nothing in speed by the reduction of the power of the engine. If the latter has been reduced to 60 per cent of its amount at low levels, so has the resistance and power required, so that the speed realized should remain the same.

Such would indeed be the case if this were all; but unfortunately other considerations enter, and the simple relation of uniform speed at varying altitudes cannot be realized without compensating features.

Thus if at a constant speed and constant angle of attack for the wings the resistance to propulsion is only 60 per cent as great at the altitude of 15,000 feet as on the ground, it is unfortunately the same for the lifting force developed by the wings. This also is only 60 per cent as great, while the weight of the machine remains sensibly constant at all altitudes. Let us grasp this fact clearly, that while, at constant speed and attitude of flight, the resistance, the lift, and all other aerodynamic forces involved vary directly with the density of the air and decrease with the altitude, the weight of the machine and the lift necessary for support remain sensibly unchanged. Hence at the same altitude of flight the lifting force at altitude and under the same speed will no longer support the plane, and unless something is done it would be unable to maintain horizontal flight at such altitude.

Two courses are, then, open for consideration, as follows:

(1) We may seek to increase the speed until at such increased value the lift will equal the weight of the plane. Under the conditions assumed this would involve an increase of speed of about 30 per cent, thus increasing the resistance to propulsion by nearly 70 per cent, or bringing it back to its value at low altitude. But this resistance overcome at the increased speed would mean an increase in the required horsepower of 30 per cent as compared with that normally developed at low level, while with the actual indraft of air, and even allowing for the increased speed, only some 78 per cent of this, or 60 per cent of the needful amount, would be developed. Hence no such speed could be realized, and the support of the unvarying weight in the rarefied air cannot be realized in this manner, and must be sought otherwise.

(2) Instead of seeking for the necessary lift by increased speed, we may seek it by changing the angle of attack—by changing the flying attitude of the plane so that at the same speed, for example, the lifting force will be greatly increased. In this manner the needful lifting force may indeed be realized. But unfortunately with the increase in lifting force will come also an increase in head resistance, not proportionally, but still a definite increase. This will mean that the actual resistance at, say, 15,000 feet elevation will be greater than 60 per cent of that at low elevation, and with 60 per cent of the power available per cycle the original number of revolutions cannot be maintained and a reduction in speed will result. With this reduction in speed will come a further loss in lifting effect and need for a further change in the angle of attack with increased head resistance; until finally, at some reduced speed, a condition will be found where the needful support for the weight of plane may be realized and the resistance to propulsion can be met by the thrust or pull developed at the propeller. In these conditions horizontal flight again becomes possible, but at a speed somewhat below that corresponding to low altitude conditions.

In addition we must reckon on a diminished efficiency of the engine with decreased power, and with the probability of a loss in propeller efficiency with the resultant change in speed. Thus if an engine is primarily designed to work at its best efficiency and under its best conditions at or near full atmospheric pressure and density, it will not work with equally good efficiency at high altitudes in rarefied air and when developing only about one-half the power for which it is primarily designed.

In brief, at an altitude of, say, 15,000 feet the plane must fly at a less advantageous angle of attack but with more resistance, and that the engine will be able to burn only about 60 per cent as much fuel and will transform the resulting heat less effectively than when at low altitudes. Therefore, the power developed will be less than 60 per cent and insufficient to maintain the same speed; and with diminishing speed there may be further loss of efficiency in the propeller and a further loss of speed, until finally matters become adjusted at some value usually definitely and sometimes considerably less than that corresponding to low-level conditions.

As an over-all practical result an airplane normally loses horizontal speed as it ascends to higher altitudes.

Confronted with this fundamental fact, what is to be done? Such loss of speed, especially in a military sense, is or may become very serious, and one of the large and definitely outstanding problems in aeronautical engineering at the present time centres about the possible ways and means of meeting this condition.

The obvious proximate solution is to avoid, so far as may be, the decrease in the amount of air handled per intake stroke of the piston as the plane ascends to higher and higher altitudes.

Broadly, two courses are open. First, we may definitely and frankly design the plane and engine for a certain desired performance at a given altitude, say 15,000 or 20,000 feet. This is a straightforward problem in aeronautical engineering. Given the desired schedule of operation and the altitude, we can determine the resistance to be overcome and the horse-

* The Sixth Wilbur Wright Memorial Lecture, read before the Royal Aeronautical Society. Concluded from the last issue.

power required, and can design the engine accordingly. In such case the volume of the cylinders will be suited to the rarefied air in which the engine is to work, and all proportions and details will be worked out on this basis.

It will be obvious that such an engine will have much too large a piston displacement volume when at low altitude—that is, it will be over-size and over-powered relative to the plane. In fact, operation near or on the ground under the same adjustments as at altitude would be quite out of the question. Means must therefore be provided for reproducing, when on the ground or at low altitudes, substantially the operating conditions at high altitudes and low air density—that is, the conditions for which the engine was designed. This may be most conveniently done by throttling down the air intake so that while air at or near full sea level density may surround the engine, it will be reduced in pressure at the intake throttle to such a degree that the amount actually taken into the cylinder will only equal that which would normally enter, without throttling, at high altitude.

On the other hand, we may definitely design the engine for operation at or near sea level and with size of cylinders and all proportions and adjustments worked out accordingly, and then by a supplementary device endeavor to maintain or to nearly maintain such conditions within the engine itself even if it is at high altitude and surrounded by air of a lower density.

This solution calls for some supplementary form of compressor or equivalent device which shall operate on the rarefied air as a first stage and raise it from the low pressure characteristic of the altitude up to or nearly to normal low altitude pressure and density.

Each of these alternatives represents a perfectly possible solution. Each has its special advantages and disadvantages. Each has its advocates as a solution of this important problem.

The first solution is the simpler of the two, since it involves no special or additional device for compressing the air. It does, however, mean extra weight in the engine which is always there and which will reduce correspondingly the net carrying capacity of the plane.

On the other hand, the compressing device of the second solution is not easy to realize satisfactorily and it also involves extra weight, though presumably less than in the case of the first solution. Again, its operation as a separate or independent unit for realizing a preliminary compression of the air is less efficient than to do the whole compression in the engine itself and by the engine piston as in the first solution. Only extended and careful trial will presumably be able finally to decide which is on the whole the better solution of the two.

The reserve necessary with regard to military matters makes it unwise to attempt to give any account on this occasion of just where the matter stands with regard to this problem, but it will at least be safe to note that it is a problem which is attracting much attention and study on the part of the various Allied Governments, and that much valuable information is being developed, and on which we may hope that some satisfactory solution may be based.

The Airscrew

We now turn our attention for a few moments to one of the most intricate and interesting of the many problems presented to us, that of the airscrew or propeller.

The function of the airscrew is, of course, to take the torque of the engine and to transform it into a propulsive thrust; or otherwise to take the power given by the engine to the crankshaft and transform it into driving or propulsive power for the airplane. The problem is further complicated by the fact that, expressed in terms of a power relation, it is not simply the question of an engine handling so much power over to the airscrew for the latter to transform into propulsive power. Instead, the power which the engine itself can develop is dependent on the propeller and likewise on the airplane to which they are both attached. We have here, in consequence, a series of complicated implicit relations, and from which the propulsive characteristics of the plane-propeller-engine combination take their origin. In fact, it must never for a moment be forgotten that the moving airplane is in effect an airplane-motor-propeller combination and that no one of the three can be determined independent of the other two.

Without entering into any detailed discussion of this problem, it will be clear that the airscrew will exercise a controlling in uence on the power which the engine can develop. Thus it is evident that an aeronautical engine, in order to develop power, must be permitted to move its pistons, to revolve its crank-shaft, in other words, to make revolutions; and, other things equal, the power developed will vary directly with the revolutions which can be realized. Again, it is easy to see that the size and amount of surface of the airscrew blades will present a controlling feature regarding the revolutions which can be realized. Thus the airscrew may be enormously oversize, too large in diameter and presenting a large and unwieldy surface to the air. Suppose this to be the case with a plane of size suited to the airscrew, but not to the engine—that is, the engine is far too small for either airscrew or plane. In such case the engine simply will not be able to make its normal number of revolutions. It will be held down by the excessive resistance to rotation presented under such circumstances, and may thus develop far less than the normal power which it is capable of under proper conditions. Many other combinations may occur which we cannot stop to discuss or even to mention. Broadly speaking, the plane, the engine and the airscrew, as the propelling agent, form a most closely knit combination, and each interacts in a more or less controlling manner on the operation of the other two.

In order even to make a start with the problem of the airscrew, it is therefore necessary to assume conditions regarding both the plane and the engine. If these conditions as assumed are then realized in practice, and if the design has been well carried out, the anticipated results may be reached. If, on the other hand, the assumed conditions are not realized as regards the plane and the engine, then no matter how well the design of the airscrew may have been carried out, the anticipated results will not be realized. No matter how good the airscrew may be by itself, no matter how carefully designed and constructed, no matter how faithfully it may be able to realize the conditions for which it is designed, if there are not the conditions under which it is actually placed for service, the results, economic and otherwise, will be unsatisfactory; not necessarily by reason of any fault in the airscrew as such, but due simply to its lack of adaptation to the conditions of operation. An effective airscrew is therefore not only one which is properly designed and constructed in itself, but also one which is permitted to operate under the conditions intended and contemplated in the design.

The general problem of the airscrew is by no means, however, to be classed distinctively as outstanding. Instead an enormous amount of work has been done on it, both theoretically and experimentally, and in its main features it has been brought fairly within the limits of a solved problem. There have been three modes of approach, briefly as follows:

(1) The analysis, geometrically, of the blade of an airscrew into a series of elements occupying each a narrow strip running across the blade from leading to following edge and making up, by their summation, the blade as a whole. Each of these elements or strips is then considered as, in effect, a little elementary aerofoil and for which the usual aerodynamic characteristics are readily determined, either by direct experiment on a model or by selection or interpolation from and among the large amount of available data regarding such aerofoils which have already been submitted to experimental investigation. With such data in hand relating to the series of elements going to make up the blade, it is a matter of simple computation to combine them in such manner as to represent the action of the blade as a whole, under the conditions assumed, and thus in general terms the problem is solved.

(2) A law of similitude is assumed and a small model propeller is tested out experimentally and under conditions which permit, under the law of similitude assumed, the translation of the *observed* results for the model into the *probable* results for the full-sized airscrew.

(3) Full-sized airscrews are tested out as nearly as may be under flying conditions, and are made the ultimate basis of design.

The limitations of Method No. 1 arise from the following:

(*a*) The co-efficients derived for aerofoils correspond to straight line motion between the air and the foil, whereas in the airscrew the relative motion is in a helical or spiral path.

(*b*) The actual velocities for which such co-efficients are derived are usually for speeds not exceeding 60 or 70 miles per hour, whereas the actual speeds of the tip elements of airscrew blades may move at speeds of 500 m.p.h. and upward. The extent to which the usual square of the speed law may be extended to such values is not as yet fully known.

(*c*) The co-efficients used are derived for the various aerofoil sections or elements individually, whereas in the actual airscrew they all act conjointly or collectively in making up the airscrew blade.

Application of Method No. 1 cannot therefore be made except in so far as it is justified by actual and final experience on full-sized forms under flying conditions.

Method No. 2 (that with reduced size models) has the limitation that the law of similitude employed is of necessity not exact but approximate, and the degree of reliance which can be placed on results thus found can again only be determined by ultimate reference to full-sized forms under flying conditions.

Method No. 3 (that with full-sized forms under actual flying conditions) has the limitation of very high cost, both in equipment and time, and as a result of which only a relatively small number of forms can actually be subjected to adequate test in this manner.

Again, Method No. 1 (that of computation based on co-efficients determined by laboratory experiment) has the advantage of requiring only a pencil and pad of paper with a table of predetermined co-efficients. No. 2 (that with the small models) has the advantage over No. 3 of relatively small cost, of permitting the tests to be carried out in a wind tunnel with all conditions under control, and finally to permit of carrying quickly through the test program a very large number of types and forms. It should perhaps be stated here that as between Methods No. 1 and No. 2, the latter is accepted as much the more reliable of the two. In fact, it is not too much to say that when used with judgment it furnishes a very satisfactory and well-nigh universally accepted method for dealing in a laboratory way with most problems of airscrew design and operation.

These phases which thus stand out represent in effect the lack of an adequate correlation between the three methods of approach as above described.

It is obvious that if we could develop an adequate and reliable correlation between the results of the computation according to Method No. 1, and the final test under flying conditions according to No. 3—if, in other words, we could adequately determine the error of No. 1 and hence the correction to be applied in any given case, then a pencil and pad of paper would go a long way towards furnishing the material for the solution of the problem of airscrew design, once that we are permitted, of course, to assume a definite set of operative conditions.

Or, again, if we could know more accurately and more widely the character and amount of error to be anticipated in the use of the small models according to Method No. 2, we should be in a position to use the experimental model method with better assurance of definite and reliable results for the full-sized screw later to be constructed.

It seems likely that this final correlation of computation with ultimate result may best be made in two stages. The first should comprise a careful study of the relation between the results derived by the computations of Method No. 1 and the model tests of Method No. 2. Such a correlation would then permit us to pass readily from the results by computation to the probable results by model.

The second correlation should then comprise a series of comparative tests to determine with sufficient generality of application the character and amount of correction to be applied to the results of model test in order to satisfactorily reproduce the results to be expected from full-sized forms.

This would by no means require the testing of a full-sized form corresponding to each model. If so there would, of course, be no use in making model tests. The whole program might as well be carried out directly by tests on full-sized forms. It appears reasonable to expect, however, that a well-selected and not too numerous series of tests, properly distributed among the various characteristics of form and of operation, would serve adequately to give the correlation desired.

With such correlations established we should then have two methods, Nos. 1 and 2, available for the design of airscrews, No. 1 available with no more than a pencil and pad of paper (once the standard section co-efficients determined), and No. 2, by model, ready to supply a vast amount of detailed information regarding operation under varying conditions, and which may be realized rapidly and effectively once the model is made.

If we have spent so much time over these matters relating to the airscrew it is because of its importance as an element in aerial navigation, and in order that we may the better note just what part of the general problem is still outstanding.

This, as we have seen, lies primarily in the matter of the correlation between the three methods outlined. There is, indeed, need for continuing experimental research, especially on systematically selected forms, both model and full size; and such continuing experimental work combined with carefully directed studies of correlation will go far toward giving us an assured and adequate basis for the practical solution of the airscrew problem as applied to aerial navigation.

Perhaps the widest and most important outstanding problem in conection with airplane propulsion has relation to the reaction between the plane and the propeller—the influence of the structures adjacent to the propeller on its performance, economic and otherwise, and the influence of the propeller on the plane, both as regards its lift and its net resistance to propulsion. This is a field which is largely outstanding. It must be attacked chiefly by the experimental method—by model with results checked up by comparison with full scale trials so far as practicable.

Of a closely related nature is the problem of the interaction of two or more airscrews on one shaft. This is a problem which is becoming of importance in connection with the increase in power of airplane power plants and with the fitting of more than one airscrew on the same shaft.

This likewise is a problem which must be approached experimentally—again through model research checked up by comparison with full scale tests. A beginning has been made on this most important and interesting problem, and we may expect in a not distant future to find it brought within limits of control similar to those surrounding the problem of the individual airscrew.

In addition to these problems which relate to airplane propulsion in its general aspects, and more especially when for the sake of simplicity we assume that the airplane remains under a uniform regimen as regards external conditions, there arises a problem of very great present importance, that of some form of adjustment in the technical characteristics of the plane as a whole, permitting it to be made responsive to variations in the regimen of operation, as, for example, change in the density of the air due to change in altitude, or change of regimen required for climbing flight as compared with horizontal flight.

In connection with the prime mover, mention was made of the very important problem of maintaining power at altitude in spite of the decrease in the density of the air. In reality this problem is very intimately bound up with another of scarcely less importance, that of devising means for effectively using such power for propulsive purposes. Without attempting any technical discussion of the question, it will be apparent that the whole problem of the operation of the airscrew as a means for absorbing the power of the prime mover and converting it into the propulsion of the plane will depend on the density of the medium in which and on which it operates. Again, in climbing flight a part of the weight of the airplane is carried by the pull or thrust of the airscrew. In horizontal flight it is all borne by the planes (assuming the airscrew shaft then horizontal). Hence the pull or thrust of an airscrew, and, indeed, its whole regimen of operation, may vary widely according as the plane is climbing or flying horizontally. It thus seems reasonable to conclude that for the best results there should be provided some mode of adjustment or compensation so that the airscrew, as it finds itself operating in a medium of continuously decreasing density, or as it finds itself called upon for varying amounts of thrust or pull with varying angles of climbing flight, may be correspondingly adjusted in order to give continuously the best results.

The problem is further complicated by the fact that the airplane itself needs a correlative adjustment. As we have already seen, the one factor in aerial flight which remains sensibly constant under all conditions and at all altitudes of flight is the weight of the plane and its equipment. The vertical supporting force gained from the reaction of the air must

therefore be maintained constantly equal to this weight at least for the conditions of horizontal flight, while for climbing flight the weight will be divided and borne partly by the supporting planes and partly by the airscrew. The problem of the economic use of power at varying altitudes and under varying angles of climbing flight involves, therefore, the following chief elements:

The weight of the plane
The surface of the wings and their aerodynamic characteristics
The angle of attack of the wings
The speed
The power developed by the engine
The revolutions of the airscrew
The area and form of the blades of the airscrew
The pitch of the airscrew

These various factors react and interact in a most complex manner, and any attempt to discuss the problem in detail would carry us too far afield on the present occasion. We may note, however, that the angle of attack is the one feature about the plane which may readily be varied, while there is no feature of the propulsive agent, the ordinary airscrew, which admits of equally simple correlative variation. What is needed with regard to the airscrew is, indeed, some means of realizing an adjustment correlative to the change in the angle of attack for the plane. To this end a change of pitch is most suitable, some means of varying, at the will of the pilot, the pitch of the screw in order that with the fixed diameter and area of surface, and with the work available per revolution of the engine as affected by the density of the air, the pitch may be so adjusted as to secure the number of revolutions best adapted to the economic use of the power given out by the prime mover. This will then insure the thrust needed to overcome the resistance of the plane at the angle of attack and speed which, taken conjointly, will give the lifting force needed to support the weight of the plane, either in whole or in part, according as the plane is flying horizontally or climbing.

All of this somewhat complicated statement means simply that what is wanted is an airscrew with blades adjustable for pitch. Such an airscrew may be realized by so pivoting the blades that they may be turned about a radial axis, thus changing their angle relative to the axis of the screw itself. Extreme changes of such a character result in a very wide variation of pitch from root to tip, and in the end will result in a serious loss of efficiency. There are, therefore, two problems involved:

(1) The aerodynamic problem of determining the best form and proportions of an airscrew, the blades of which are intended to be pivotable in this manner, so that under the widely changing conditions of flight which may be met with there may be effective operation and a well-sustained efficiency.

(2) The mechanical problem of so designing and building an airscrew with adjustable blades that it will meet the rigorous requirements imposed upon it by the exacting conditions of airplane navigation.

It is perhaps not too much to say that the first problem is already well in hand. We know reasonably well what forms and proportions to give to such an airscrew, and if it was only a matter of design or of the determination of form and proportion the problem could hardly be called outstanding.

As much cannot be said regarding the second problem. The practical construction of an airscrew with adjustable blades is not an easy matter. Several modes of construction have been attempted, but with only moderate success. The problem is clearly defined, of the highest order of importance, and is outstanding as one of the appliances for which the art of aerial navigation is definitely in waiting.

Stability and Control

The three fundamental requisites of an airplane are strength, movement and stability with control. We have noted some of the problems arising under the requirements of strength and movement or propulsion. We may now turn very briefly to a glance at the situation regarding stability and control. Any detailed discussion of these problems would be quite out of the question on the present occasion, and time in any event will only allow us a brief glance at the general situation.

Regarding stability and control, it is not too much to say that the general principles underlying these characteristics of an airplane are now reasonably well understood, due largely to the splendid theoretical and experimental investigations initiated by British scientists and to which certain workers in the same field in the United States may have contributed something, and by no means overlooking certain important contributions by French and Italian investigators. These investigations, both analytical and experimental, have placed the study of these subjects on a reasonably sure foundation, and have served to mark out the way to secure any desired degree of stability which may be desired or which may be consistent with other valuable qualities. We are here confronted with one of those situations, so frequently encountered in scientific and technical work, where a choice must be accepted on some middle ground between wide extremes, and where the attempt to secure some desirable quality in high degree may lead to a limitation of desirable qualities in other directions.

So it is with stability and control. If stability is carried to an extreme, then mobility and quickness of maneuvering are reduced and control in the sense of ready response is lacking. For military purposes, especially for machines of the fighting type, where mobility is of the highest importance, this would be a serious shortcoming, and hence such machines cannot be given too much stability in the ordinary sense of the term. On the other hand, for heavy machines of the bombing type, where mobility of evolution is not so vitally important, the margin of stability may be greater. Going to a still further extreme, it is perfectly easy to build a safe, moderate speed family carriage sort of machine which will be stable and secure under almost any conditions likely to develop. Such machines would be scorned by fighting pilots, but when civil aeronautics begins to come into its own after the war and under peace conditions, and there comes a demand for safe machines for civil purposes, including family outings for the week-end from the city to the country or to the seacoast, then we may anticipate a larger recognition of the qualities making for safety and stability, and we shall find machines provided having such characteristics and in practically any desired degree. Here again, however, there will be degrees of choice, because it will be found that with too high a degree of stability what may be termed the riding qualities of the plane will be poor, while with low stability the riding qualities may be much smoother.

The general problem is, therefore, pretty well solved, so far as the groundwork is concerned. This does not mean, however, that there is nothing further for us to learn in this connection. There are many problems of a detailed nature inviting the student of this fascinating field of study, and the solution of which will serve to round out and broaden our general grasp of the problem. In particular, we need further study on the interaction between elements which insure stability and those which permit mobility and readiness of response to control agencies, to the end that we may control more effectively the combinations which may be desired regarding stability and mobility of evolution.

Again, while the elements of control are well understood, there is room for further study as to the best means of actually developing the control forces required and of applying them to the plane itself. These are partly aerodynamic and partly structural problems, each phase reacting more or less on the other.

One instance of problems of this character will serve to illustrate the type.

We know that an airplane is provided with rudder surfaces of two kinds, one to determine movement in a vertical motion, up or down, and the other to determine horizontal motion, right or left. But these motions, vertical and horizontal, assume that the plane itself is horizontal, or sensibly so. However, when a plane is circling on a steep spiral or making a quick turn, it is inclined or "banked," in order to avoid side slipping, until, in extreme cases, the wings are nearly vertical, and frequently much more nearly vertical than horizontal. In such cases the functions of these control services are reversed. Those which, with normal aspects, serve to produce movement right and left will now serve to determine motion rather in a vertical direction, and those which formerly served for movement up and down will now serve to determine motion to the right or left. For intermediate angles of bank, each set of control surfaces will give control forces in both directions, up or down and right or left.

Now it is by no means sure, having in view this double and interchanging function between these two sets of surfaces, whether we have as yet realized the ultimate and best arrange-

ment either as regards the surfaces themselves or their control by the pilot.

It seems decidedly probable that we have not, and that some arrangement yet remains to be devised which will be more effective in the matter of this double and interchanging function of control, and simpler in its relation to the pilot.

There still remain two large and important fields, rich in aeronautic problems. These are armament and instruments. I shall attempt no more than the briefest general reference to these two classes of problems.

Those arising under the head of armament are, of course, strictly military in character, and but little of interest could, in any event, be said in a public address. Such problems relate naturally to the number, type and size of guns to be carried, their mounting and special sights; bombs and devices for carrying, aiming, dropping, etc.; questions of armor and protection of vital parts against gunfire or shrapnel bursts, etc.

Expressed in their most general terms, these problems resolve themselves into an attempt all along the line to meet the requirements imposed by the desired military uses of the plane, and to anticipate or improve upon the devices and designs of the enemy in the same fields.

Regarding instruments, little more specific can be said. This field does, however, bristle with problems of the highest interest to the scientist, and may well challenge his best efforts. It is interesting to note the extent to which the modern airplane has become a flying meteorological and physical laboratory. Thus, a recent list of airplane instruments shows some 25 or 30 different instruments and devices, not indeed all to be carried on one plane, but all included in the general areonautic military program, and each serving some specific, important purpose.

With these instruments, as with armament, the problems reduce themselves to an effort to meet the military or the navigational and operative requirements of the situation, and in these days of war, in particular, to anticipate or improve upon the similar devices and designs of the enemy.

Much of the work relating to these problems under armament and instruments is already done and well done. There do remain, however, many problems, especially of detail or of improvement, and which must be considered as outstanding; but of these I shall attempt no mention or discussion.

By way of conclusion, reference may, for a moment, be made to a problem of the most vital and far-reaching economic importance, and which will be upon us with the arrival of peace conditions. This is the problem of the best economic utilization of the enormous investment which has been made in aeronautical production, expressed in terms of money and human time and energy, and now represented by factories, machinery and equipment, finished product, trained industrial organizations, human skill and productive capacity.

The discussion of such a problem might well occupy our careful attention for the entire hour, but I can no more than mention it here by name. We can, however, scarcely overexaggerate its importance, and the appointment of important commissions in England and in the United States for the study of the problems arising under this general head is an evidence that their serious import is appreciated, and we may hopefully await suitable measures of adjustment against the day when we may again turn our thoughts to the occupations of peace.

And so with all our problems; we can only look hopefully forward for the future to give to us such measure of answer as our patience and study may merit.

Desirable Aeronautical Inventions

The Inventions Committee of the British Air Ministry has issued a memorandum on desirable aeronautical inventions and improvements which should be of considerable value.

Generally speaking, and as far as the period of the war is concerned, no very startling change in the present types of aircraft is expected, although improvements in parts and also in details are always possible and may produce very important results.

The stage of development in construction which has now been reached is such that major improvements can only be expected from those possessing the requisite scientific and mechanical knowledge, skill and experience. Thus, radical changes in the shape of the wings of airplanes, the body, and the airscrews are only possible after long and patient research carried out in aeronautical laboratories.

Helicopters, Ornithopters and Orthopters.—Again, many inventors have forwarded proposals for helicopters and aircraft of this nature which, if an efficient design can be produced, would possess certain advantages, though probably not so great as was once imagined. Others have suggested flapping wings and rotary planes.

Such schemes do not give any promise of being developed for use during this war, and in any case would require some years of experiment before they could be regarded as practical proposals.

Minor Details.—As regards minor improvements, inventors should bear in mind that many details, such as turnbuckles, clips, etc., are now standardized, and a change would only be justified by some very marked superiority.

Safety Devices.—Safety devices for preventing crashing of the machine and the pilot form a numerous class. The chief of these is the parachute, either applied by a harness to the pilot or directly attached to the machine. Those who have seen a passenger dropped by a parachute from an airplane for exhibition purposes often fail to realize the conditions under which a parachute may have to be used as a safety appliance. Then the machine may be out of control, dropping at a velocity of 150 to 200 miles per hour, or spinning downwards in flames.

Many other safety devices, such as automatic stabilizers, windbrakes, etc., have been proposed at various times. The additional weight entailed by the use of any of the suggested safety appliances must remain a very serious factor for so long as war conditions prevail.

Engine Problems.—The engine is the heart of the airplane, and on its reliability depends the safety of the pilot. Persons acquainted only with motor-car engine practice sometimes do not realize the exacting conditions under which an airplane engine must work.

The engine must be capable of running for the whole of the time of flight at its maximum power. The lubrication and ignition must be perfect, and the engine must not become overheated. The rating applied to airplane engines is its weight per horsepower, and engines are now being produced which show surprising results in this respect.

Inventions which differ radically from present-day practice (such as the internal-combustion turbine) have small possibilities of being adopted, for successive design and reconstruction entailing probably several years' work are necessary before there can be hope of satisfactory results. In view of the shortages of materials and labor at the present time, it is impossible to embark on the production of any new type unless it is demonstrably superior to existing types and possessed of definite and immediate advantages over them.

Silence and Hearing.—A subject which is intimately connected with the power-plant is its noise. The constitutes one of the disadvantages of an airplane.

For night flying a method by which it would be possible to hear from one airplane the approach of another would be of great advantage. The engine can be silenced without serious disadvantages, but the noise of the airscrew and the hum of the wires are so great that silencing the engine is not sufficient.

Bomb Ideas.—Many proposals for the projection of bombs and grenades of flame and of poisonous gases have been received.

The trailing bomb or grapnel for attacking enemy aircraft and submarines is a favorite suggestion from inventors. This device was tested before the war and at various times since, but has been abandoned in favor of more effective methods.

Instruments.—Many hundreds of inventions and suggestions for inclinometers and instruments for straight flying and accurate bomb-dropping have been investigated. Efficient and well-designed instruments for these purposes have been available for some time past, but it is quite possible that improved forms may be produced, though it is scarcely likely that this can be done by anyone who does not possess the necessary scientific and mechanical knowledge required for an investigation of this nature.

Anti-Aircraft Defence.—Anti-aircraft devices of various kinds are constantly suggested, but now contain very little new matter for consideration, as such proposals have received the careful attention of the authorities for a long time past and have been the subject of much trial and experiment.

The Air Mail Service

The Air Mail Service, which the Post Office Department inaugurated on the New York-Philadelphia-Washington route on May 15, was operated by Army aviators, detailed for this purpose by the War Department, until Aug. 12, when it was entirely taken over by the Post Office Department. On that day a new postal aerodrome, situated at College Park field, was inaugurated at the Washington terminal of the air mail route.

Coincident with the transfer of the air mail service, six civilian postal airmen and a staff of civilian mechanics and riggers entered upon the discharge of their duties, in replacement of the detailed military personnel, under orders of Capt. B. B. Lipsner, appointed on July 15 superintendent of the Aerial Mail Division of the Post Office Department.

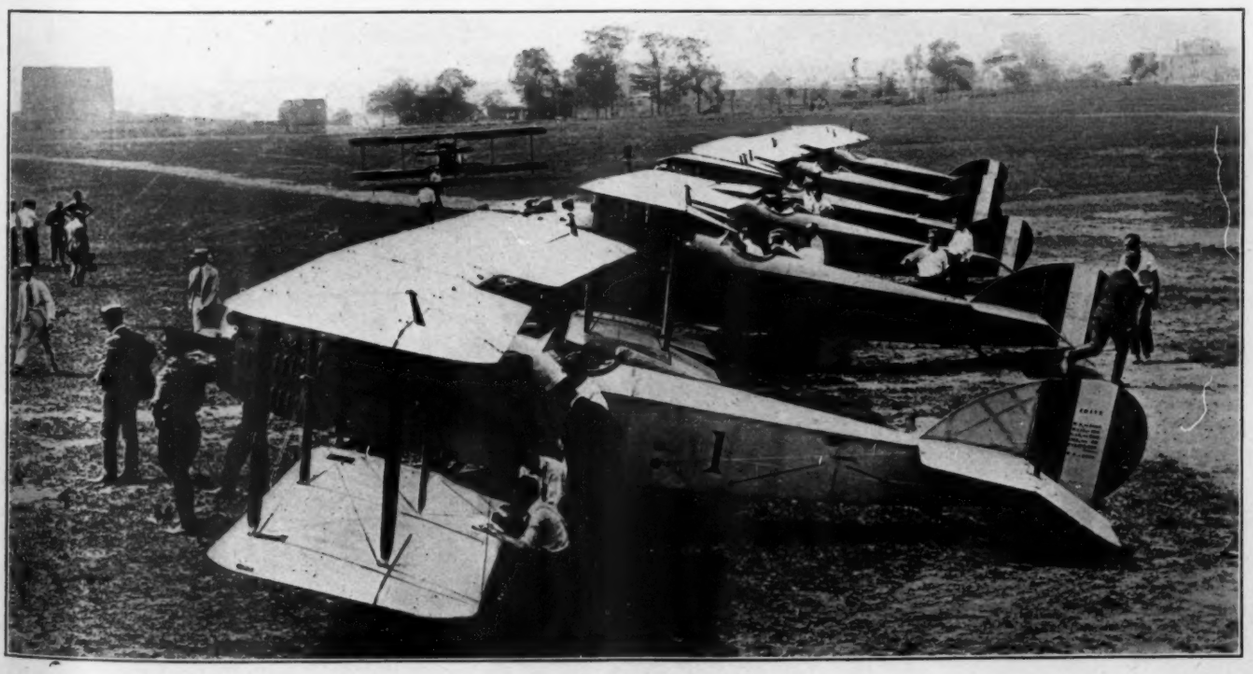
Captain Lipsner, who had been acting as assistant to Captain Willoughby when the latter was in charge of the air mail service, resigned his commission in the Army to accept from the Postmaster-General his new appointment. He is a recognized authority on transportation and mechanical maintenance, and was instrumental in the installation of the air mail service.

The postal aviators who will carry the mail on the Washington-New York route are expert civilian fliers and instructors in aviation. The list comprises Max Miller, former flying instructor at San Diego, Cal., 1000 hours in the air; Maurice A. Newton, Brooklyn, N. Y., experimental flier and instructor, 1100 hours in the air; Robert Shank, military flying instructor, Dallas, Texas., 1200 hours in the air; E. V. Gardner, advanced flying instructor, Dallas, Texas, 1450 hours in the air, and V. P. Hollingworth, military flying instructor, Dallas, Texas, 1000 hours in the air. The reserve fliers are E. Leroy Langley and L. B. Boldenweck.

The staff of mechanics who will maintain the equipment are now at the factory of the Wright-Martin Corp., New Brunswick, N. J., where the Hispano-Suiza engine is manufactured, for observation of the latest developments in this industry. The expert riggers of the postal service have been detailed to the airplane factory for a detailed study of the construction of the Standard planes.

With the transfer of the air mail service to the full administration of the Post Office Department, a specially built fleet of six postal airplanes has also been placed in commission. The machines were built by the Standard Aircraft Corp. at their plant at Elizabeth, N. J., and were delivered to the postal authorities on Aug. 6. They are biplanes fitted with the 150 hp. Hispano-Suiza engine, and are capable of a maximum speed of 100 m.p.h. and a climb of 6000 ft. in 10 minutes. The load items painted on the rudder are as follows:

Weight, empty	1665 lb.
Mail	180 lb.
Gas	360 lb.
Oil	30 lb.
Pilot	165 lb.
Weight, total	2400 lb.

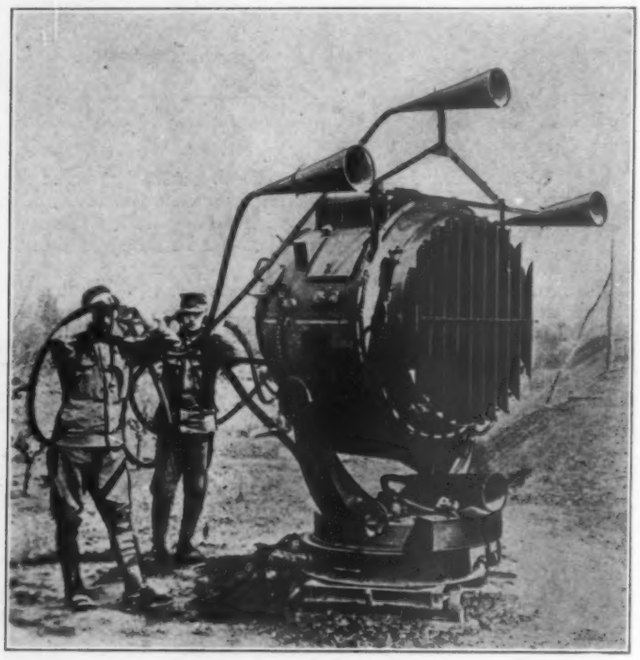


Digest of the Foreign Aeronautical Press

Flying (London), July 17, 1918

A New Fokker Biplane.—The Fokker firm have been building airplanes of the D. (pursuit) class since the inception of this type at the beginning of 1916; both biplanes and triplanes were produced, fitted with Oberursel or Mercedes engines. The latest known product of this concern, the biplane D.7, appears to be of very recent manufacture because the engine is a 180 hp. Mercedes and the wings of the machine examined bore the date May 1, 1918.

The most interesting features of the Fokker D.7 are the wireless truss of the wing panels and the abnormal dimensions



AUSTRIAN SEARCHLIGHT FITTED WITH AIRCRAFT DETECTORS
(C) *Underwood and Underwood*

of the wing section, both of which are well known from the Fokker triplane. Unlike the latter, however, the D.7 embodies two wing spars of deep section which are placed about 2 ft. apart. The total depth of the wing section is approximately 9½ in., the chord being 5 ft. 6 in.; the maximum thickness of the wing is therefore one-seventh of the chord. The general lines of the wing section are similar to those found on the Fokker triplane.

The wings are supported amidwings by arrow shaped steel strutting which is rigidly attached to the body by welding, and the outer ends of the wings are interconnected by N-shaped steel struts, acting apparently as ties.

The span of the upper plane is slightly under 28 ft., and that of the lower plane about 23 ft.; no precise measurements could be taken of this machine on account of its damaged condition. Both the upper and lower planes are in one piece and, of course, have no transverse dihedral; the lower plane fits into a slot formed in the body, as on the triplane. Balanced ailerons of very small area are carried.

The body, tail plane and elevator are all very similar as those of the triplane; a vertical fin is however disposed in front of the rudder which is of the balanced type.

The armament consists of two Spandau machine guns, mounted on top of the body, and firing through the airscrew by means of the usual synchronizing gear, and in addition, by a jamb-clearing device, not usually seen. From the nose to the pilot seat the body is painted a bright red, while from that point to the tail the color is white. The top face of the upper plane, the cabane, the undercarriage and the N-struts are painted red, while the bottom face of the upper plane and the entire lower plane are camouflaged with various dull colors of the usual pattern.

The Pfalz D.3A Biplane.—This machine, which has only recently been captured is a development of the Pfalz D.3 type of pursuit biplane, which is well known.* The body, engine, and planes are apparently the same as in the latter model, the only alteration effected being found in the size and shape of the tail. The new tail is the same span as the old, with a one-piece elevator, but is of greater depth.

The tail of the old Pfalz biplane was remarkable for the fact that, while the top face was flat, the bottom face was appreciably convex, a feature which was assumed to serve the purpose of introducing in a steep dive a depressive force on the tail and thus flatten out the machine with less effort by the pilot. It is therefore of particular interest to note that on the D.3A type the tail is symmetrically cambered on both faces and appears to be set parallel to the line of flight.

Aeronautics, July 17, 1918

The Year's Work of the Royal Air Force.—The following official statement relative to a year's work of the Royal Air Force was issued on July 13:

During the year beginning July 1, 1917, and ending June 30, 1918, 2,150 enemy aircraft have been destroyed by the British on the Western Front alone, whilst 1,083 enemy aircraft have been driven down out of control.

During the same period Royal Air Force units, working in conjunction with the Royal Navy, have shot down 623 enemy aircraft.

In the same period 1,094 of our machines have been reported missing, whilst of those working with the Navy 92 are missing.

Thus, in the North, during the year, the British alone have accounted for no fewer than 3,856 enemy machines, the number of British machines missing being 1,186.

Turning to another theatre of war, during the period of April to June of this year, on the Italian Front, the British have destroyed 165 enemy machines and driven down six out of control, whilst British machines missing were 13.

On the Salonika Front, between January and June, 21 enemy aircraft were destroyed and 13 driven down out of control, whilst British machines missing were four.

From March to June, in Egypt and Palestine, 26 enemy aircraft were destroyed and 15 driven down out of control, 10 British machines being missing.

Thus, during the present year, in these outside theatres of war, 246 enemy aircraft have been accounted for, whilst 27 British machines were missing. So that between July, 1917, and July, 1918, the British have brought down very considerably over 4,000 enemy aircraft, whilst British machines missing have only slightly exceeded 1,000.

Remarkable as has been the progress made in aviation during the war, it must be admitted that we have not yet passed the stage at which all aerial operations are materially affected by weather conditions.

In effect there are from the airman's standpoints, two kinds of days—flying days and "dud" days. In the same way, the night flying airman divides each month into "light" and "dark" periods, according to the phases of the moon.

These facts require to be borne in mind in reviewing any record of aerial operations. One fact emerges clearly from all records of aerial operations, and this is that British superiority and strength in the air in all the theatres of war have progressed rapidly and continuously. From this it should be safe to assume that when the new factor of America's output, both of aircraft and personnel, begins to enter into the situation, actually in the fighting zones, the aerial ascendancy of the Entente Allies should give them very great advantages.

In aerial warfare more perhaps than in any other branch there can be no standing still. Having regard to unavoidable war wastage, mere maintenance demands great and unceasing effort. But continuous expansion is what is needed, and that, in conjunction with maintenance, is only possible as the result of uninterrupted co-operation and complete devotion to the end in view on the part of all the multifarious groups of workers of all grades connected with the war in the air.

* See the June 1, and July 15, 1918 issues of AVIATION.

News of the Fortnight

Aero Manufacturers in Convention

Officials, engineers and production men of the leading aircraft manufacturers of the country, who comprise the Manufacturers' Aircraft Association, gathered in Boston on Wednesday, Aug. 14, for three purposes:

1. To inspect the plants of the Sturtevant Aeroplane Co. at Jamaica Plain and the Burgess Co. at Marblehead.
2. To hold the association's monthly directors' meeting.
3. For relaxation and entertainment between times as the guests of the Sturtevant and Burgess companies.

The visitors met at the Copley Plaza Hotel early Wednesday morning. Automobiles were available to take the visitors first to the Sturtevant airplane factory at Jamaica Plain. There Benjamin and Noble Foss conducted the party through the plant, which has quadrupled in capacity during the past year.

Leaving the Sturtevant plant, the automobiles took the manufacturers to the docks of the U. S. Shipping Board merchant marine training station at East Boston, where, through the courtesy of Mr. Howard, in charge of the Boston training district, they embarked on the Shipping Board's steamer for a sail down Boston harbor and around to Marblehead, Mass., where the Burgess Company is located. The directors of the association held their monthly meeting on board ship, where afterwards a buffet luncheon was served. In Marblehead Bay the guests were transported in the boats directly to plant No. 2 of the Burgess Company, one end of which opens directly on the water.

F. H. Russell, general manager of the Burgess Company and president of the Manufacturers' Aircraft Association, and his assistants conducted the guests through the Burgess plants, which are engaged entirely with Navy work.

Leaving the Burgess Company, the manufacturers were taken in launches across the bay to the Corinthian Yacht Club, where a swim was indulged in.

Dinner was served at the Corinthian Yacht Club. Mr. Russell introduced several speakers, including Judge W. B. Crisp, counsel for the association; J. G. White, president of the Springfield Aircraft Co., and H. B. Mingle, president Standard Aircraft Corp.; Benjamin Foss of the Sturtevant Co.; Mr. Willys of the Curtiss Co., and Mr. Howard of the Shipping Board, who told of successful efforts which are being made to train thousands of young officers for our rapidly increasing merchant marine.

The visiting manufacturers were greatly impressed with the hospitality of the Burgess and Sturtevant companies and the Shipping Board, to whom they are indebted for a very interesting and instructive day. The opportunities afforded for the manufacturers and their representatives to get acquainted were also much appreciated.

A list of the manufacturers, their representatives and guests follows:

Aeromarine Plane & Motor Co., J. M. Upperen and Mr. Newman; Standard Aircraft Corp., Harry Bowers Mingle, Max Finkelstein, Mr. Taylor and Mr. Penniwell; L. W. F. Engineering Corp., A. H. Flint; Thomas-Morse Aircraft Corp., W. T. Thomas and Raymond Ware; Rubay Manufacturing Co., L. Rubay, A. R. Warner and P. Lacroix; Gallaudet Aircraft Corp., Edson Gallaudet; Springfield Airplane Co., J. G. White; Curtiss Aeroplane & Motor Corp., J. P. Tarbox and J. N. Willys; Manufacturers' Aircraft Association, H. H. Bradley, Judge W. Benton Crisp and Walter V. Taylor; Wright-Martin Aircraft Corp., Mr. Hoyt; Dayton-Wright Airplane Co., H. E. Talbot, Jr.; Burgess Co., F. H. Russell, J. W. Curtis, Mr. Davis, S. W. Wead, P. W. Bliss, F. C. Paine, E. J. Barnard and M. L. Skene; Sturtevant Aeroplane Co., Noble Foss, Benjamin S. Foss, W. E. Barrett, C. J. Cawley, G. H. Nobbs, F. S. Chanonhouse, J. J. McElroy, H. F. Byers and A. L. Priddy; B. F. Sturtevant Co., Mr. Morton, Capt. Lester Watson and Lieut. Henry Bryan, U. S. A.; Lieut. H. C. Wesson, Lieut. P. C. Whitmer and Lieut. Parker Kemble, U. S. N.

Army Ordnance Department Contract

The Army Ordnance Department has awarded a contract to the Champion Spark Plug Co., Toledo, Ohio.

Lieut. Col. Clark in Charge of Airplane Design

Lieut. Col. Virginius E. Clark, one of the old fliers of the Army, having passed his "Brevet" tests in 1913, is now in charge of Airplane Design in the Technical Section of the Bureau of Military Aeronautics. Until recently he was chief aeronautical engineer for the Army, member of the Joint Army and Navy Technical Board for Aeronautics and member of the Joint Army and Navy Board for Zeppelins.

LIEUT. COL. V. E. CLARK
Photo Edmonston

Colonel Clark was the airplane expert for the Army on the Bolling Aeronautical Mission that went to Europe last summer and was the commanding officer of McCook Field, the Army's aeronautical experimental station, during its construction and organization period, and until he was ordered to Washington for duty. In Europe he is recognized as one of America's foremost authorities on airplane engineering.

DH Planes in Reconnaissance Work

The Secretary of War made this statement Aug. 16:

"I have a cablegram from General Pershing which tells me that early in the present month of August a complete squadron of eighteen American-made De Haviland-4 planes with Liberty engines conducted a reconnaissance back of the German lines and successfully returned without loss. General Foulois personally led the expedition. Lieut. Blair Thaw is also reported as having been with the expedition."

This is the first official report received or at least made public in this country of the participation of all-American DH machines in the activities of the Western front. Though not stated, it is probably the first airplane squadron manned entirely by American pilots to fly over the enemy lines.

New Martin Combat Machine Tested

According to the Cleveland *Plain Dealer*, a twin-engined combat airplane produced by the Glenn L. Martin Co. of Cleveland, Ohio, made its trial flights on Aug. 17. Eric Springer, test pilot for the company, took the machine up 9000 ft. and remained aloft half an hour for a general test.

The machine is stated to be fitted with two Liberty-12 engines and to have a crew of three, consisting of a pilot, a gunner and an observer.

British Electrical Expert Arrives

W. O. Kennington, European consulting engineer of the Remy Electric Co., and associated with Walter H. Johnson of London, England, is in this country on a special mission for the British Government.

The purpose of Mr. Kennington's visit to the Remy Co. is to discuss the electrical equipment being supplied the Admiralty, Air Board, Mechanical Transport Department and the Mechanical Warfare Department of the British Government. These departments include motor cars, motor trucks, tanks, airplanes and U-boat chasers which are Remy-equipped.

Mr. Kennington, a native of Great Britain, has been intimately connected with many new developments in automotive electrical equipment for many years and for several years was assistant chief engineer of the Remy Electric Co. at Detroit, Mich., and Anderson, Ind.

About two years ago Mr. Kennington resigned from this position in answer to the call of his country and has been serving the British Government since.

Douglas Fir Price Date Extended

Upon the request of the industry, the price-fixing committee of the War Industries Board has extended the date of the expiration of the maximum prices on Douglas fir lumber logs from Sept. 15 to Oct. 15, 1918.

Export Conservation List

The Export Conservation List, containing various modifications of the previous list and effective July 1, has a number of items of interest to the aircraft trade. The notations indicate the supplementary information forms to be used. Among the items are the following:

Aeronautical instruments; aeronautical machines, their parts and their accessories; castor beans; gasoline; anti-aircraft instruments; castor oil (X-2); carrier pigeons; radio and wireless apparatus and all accessories (X-2); rubberized silk suitable for use in the manufacture of aircraft; veneer and plywood of all kinds, and ash, fir, mahogany, oak, spruce and walnut (X-2).

In Recognition of Loyal Service

In conformity with a recommendation of the War Department that faithful service of employes engaged in the manufacture of war materials should be recognized, the American Bronze Corp. of Berwyn, Pa., is one of the first concerns in that district to adopt the proposed policy.

Beginning twelve years ago as a modest $5000 concern, this company has enjoyed a remarkable growth and is now devoting nearly all its output to war purposes. By the American Bronze Corp.'s plan of war work recognition each employe is awarded a bronze war worker's badge, which, at the expiration of thirty days, will be exchanged for a silver badge, provided the employe has rendered faithful and loyal service. After wearing the silver badge for one month each employe will receive a cash bonus, which will continue for a period of six months, after which he is awarded a gold badge with his name engraved thereon. The gold badge entitles the wearer to the cash bonus during the entire period of his employment, provided he qualifies under the regulations.

The presentation of these badges was made a feature of a "house warming" held on Aug. 16 in celebration of the opening of the American Bronze Corp.'s new plant at Berwyn. The new structure more than triples the former capacity of this rapidly growing concern.

The exercises began in the afternoon when the new plant was formally turned over by the contractors and accepted by M. C. Dittman on behalf of the company, following which E. G. Anderson gave a talk on the important part their product is taking in the carrying of the war. Mr. Dittman then explained the bonus plan, after which different department heads were called on for short talks, concluding with an address by G. D. Porter, representing the stockholders. An election of department representatives closed the afternoon exercises.

Officers of the American Bronze Corp. are John W. Watson, president and general manager; Matthew C. Dittman, vice-president and treasurer, and Richard A. Watson, secretary and production manager.

Navy Contracts Awarded

The Bureau of Supplies and Accounts, Navy Department, has awarded a contract for Douglas airplane fir to the Moore Mill & Lumber Co., Bandon, Ore., and for boxing airplanes (two contracts) to the Burgess Co., Marblehead, Mass.

Making Aircraft Radiators

At Lockport, N. Y., the Harrison Radiator Corp. has 750 men, women and boys working on airplane radiators. The factory, strictly modern in construction, is equipped with the best machinery, soldering equipment and conveying apparatus for facilitating the speedy handling of its output, wholly eliminating hand trucking about the plant.

During the last six months the Harrison concern has been engaged in manufacturing various kinds of experimental radiators, making as many as twelve types, each totally distinct in design from the other. Now the Harrison Corp. is fully prepared to do its part in carrying out the radiator program of the Aircraft Production Board.

After-the-War Cooperation

The election of Albert Brown of London as president of the Society of Motor Manufacturers and Traders of Great Britain is of much more than passing interest. Mr. Brown is one of the founders of the commercial firm of Brown Brothers, 22 Great Eastern Street, London, E. C., a company that is active throughout the entire world. He is aggressive and will bring to his office a positive drive for securing co-operation of American, British and French business men in working out the many and complex problems involved in after-the-war development. Mr. Brown is anxious to work with all agencies that have this in view and will undoubtedly receive that hand-to-hand help he is seeking in America. In a recent letter to President Dewitt Page of the New Departure Manufacturing Co., Bristol, Conn., Mr. Brown says:

"It does appeal to me that we want to try to keep the Central Powers out of our markets for some years after this war. I hope you will agree that it behooves us and the trading communities of the different countries to work together."

Du Pont Advertising Division Moves

E. I. du Pont de Nemours & Co. of Wilmington, Del., has sprung an innovation in advertising circles by equipping an immense office building solely for the use of its Advertising Division.

Through the expansion of its varied lines and the acquisition by purchase of a number of allied industries, the Advertising Division of this great company has increased to such an extent that from a payroll of eleven people in 1911 it has grown until it now numbers a force of two hundred advertising experts and assistants, under the direction of George Frank Lord, the company's Director of Advertising.

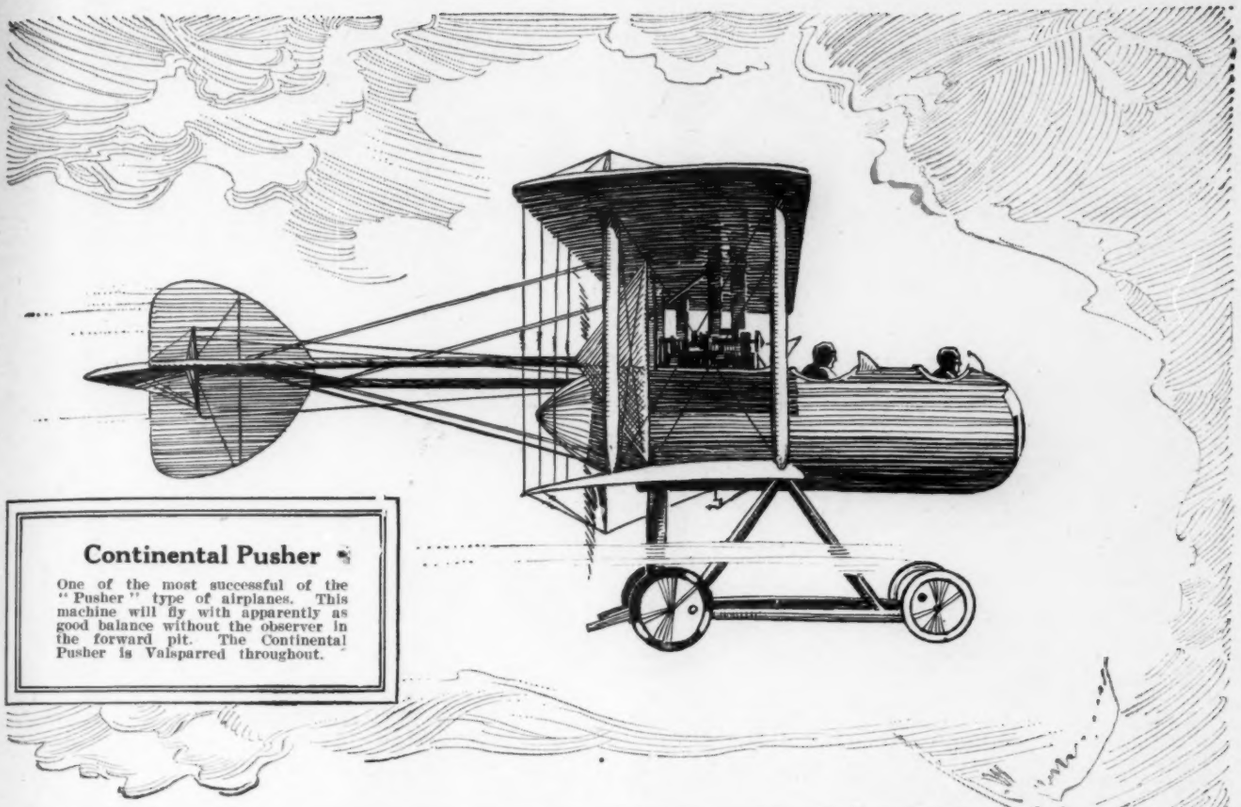
Contrary to a generally accepted impression, the Du Pont Co. is not engaged solely in the manufacture of industrial and military explosives. In reality it is the greatest diversified industrial enterprise in the world. It manufactures more than a thousand peace products which are widely used in the arts, sciences, industries and the home.

The advertising aims of the company are directed toward furnishing the public with complete information and education as to the uses and proper methods of use of their multiplicity of products. In consequence the importance of the Advertising Division has increased in proportion to the growth and expansion of the company.

The Du Pont American industries and the advertising managers of the individual companies are: The Arlington Works, A. R. Kneale; Du Pont & Harrison Chemical Works, L. B. Steele; Du Pont Fabrikoid Co., A. H. Berwald; Du Pont Dye Works, S. F. Whithe; Harrison & Bridgeport Paint Works, J. Coleman Bentley; Industrial Explosives, E. F. Carley; Agricultural Explosives, F. W. Wilson, and Sporting Powders, Edmund Doremus.

The Canadian advertising of the Arlington Co., Ltd., and the Du Pont Fabrikoid Co., Ltd., both of Canada, is in charge of J. M. Cane.

In addition to the above-mentioned industries the company recently acquired a large interest in the General Motors Co.



Continental Pusher

One of the most successful of the "Pusher" type of airplanes. This machine will fly with apparently as good balance without the observer in the forward pit. The Continental Pusher is Valsparred throughout.

The latest types of Aircraft are Valsparred

Valspar is used to protect airplanes and seaplanes because it has proved its high efficiency in long and arduous service.

Training-machines, American coast air-patrols, battle-planes on the Allied fronts, and practically every other type of military and naval flying craft are Valsparred.

Valspar is water-proof as well as proof against mud, storms and all the other trials to which varnish is subjected in the exacting service of the air forces of the Allied Governments.

Our Airplane Service Department will gladly give the benefit of its experience on request.

Valentine Products used by the world's leading airplane makers include ValsparVarnish, Valspar Bristol Enamel, Valspar LowVisibility Gray Enamel, ValsparOlive-Drab Enamel, ValsparBlack Enamel, Valspar Filler (Wood), Valspar Primer (Metal), Valspar Primer (Wood), Valspar Khaki Enamel, Valspar Aluminum Paint. Dipping, Spraying, and Brushing coatings of all kinds, Quick-Drying Insignia Colors.

VALENTINE & COMPANY

Largest Manufacturers of High-grade Varnishes in the World—Established 1832

New York Chicago VALENTINE'S VARNISHES (Trade Mark) Toronto London Boston Amsterdam

W. P. FULLER & Co., San Francisco and Principal Pacific Coast Cities

VALENTINE'S VALSPAR

The Varnish That Won't Turn White

Copyright, 1918, Valentine & Company

Gillette SAFETY RAZOR

The New U. S. Service Set—A solid metal case, heavy nickel-plated and embossed with the Insignia of the U. S. Army and Navy. Strong, thin, compact: 1¾ inches wide, 4 inches long, ⅝ inch thick. 12 double-edged Gillette Blades (24 Shaving Edges). Contains a nickel-plated Gillette Safety Razor and Blade Box. Indestructible Trench Mirror inside the lid. **$5**

Military Set No. 18—For Uncle Sam's Officers, a Gillette Combination Set, in case of U. S. Regulation Khaki twill — nickel-plated "Bulldog" Razor, indestructible Trench Mirror fitted in pocket in lid; Shaving Brush and Stick Gillette Shaving Soap in nickel-plated Holders; two Blade Boxes; 12 double-edged Gillette Blades (24 Shaving Edges). **$7**

War service is throwing the spotlight on the Gillette

There are mighty few personal belongings a man in the Service can pack around—and the greatest of his comforts is his Gillette.

Wind-chap, sun-burn, cold water, cold weather only give the Gillette a bigger opportunity to show *service.*

There isn't a mile of the battle-fronts, nor a ship of the Allied Nations, but has its Gillette users by the tens and the hundreds. The compact, portable razor that can always be depended on for *service.*

Have you seen the new Gillette Sets specially made for the fighting man? Two of them are illustrated on this page. They were designed by members of the Gillette Organization in the Service — men who know what the fighting man is up against.

Simple and compact, fit the pack, the pocket or the ditty box. No strops or hones to clutter up the kit. Blades always sharp, always ready. No Stropping—No Honing. When a man wants new Blades he can get them in any Post Exchange, Ship's Canteen, or Y. M. C. A. Hut, here in America or overseas.

Our Paris Office carries stocks — is constantly supplying the American Expeditionary Forces. Gillette Safety Razors and Blades on sale everywhere in France, England, Italy, and the Eastern battle fronts.

Gillette Safety Razor Co.
of Canada, Ltd.
73 St. Alexander St.
Montreal

Gillette Safety Razor Societe
Anonyme
17 Bis, Rue La Boetie
Paris, France

Here's the Way to Get 100% Efficiency Out of Your Gillette

Try this when you shave tomorrow morning. Lather the beard thoroughly, and rub well in — that's essential with any shave.

Put in a new blade and screw the handle down tight. If you want a specially close shave, unscrew the handle a part turn.

Hold the razor naturally and easily, and tilt the handle so you can just feel the blade engage the beard.

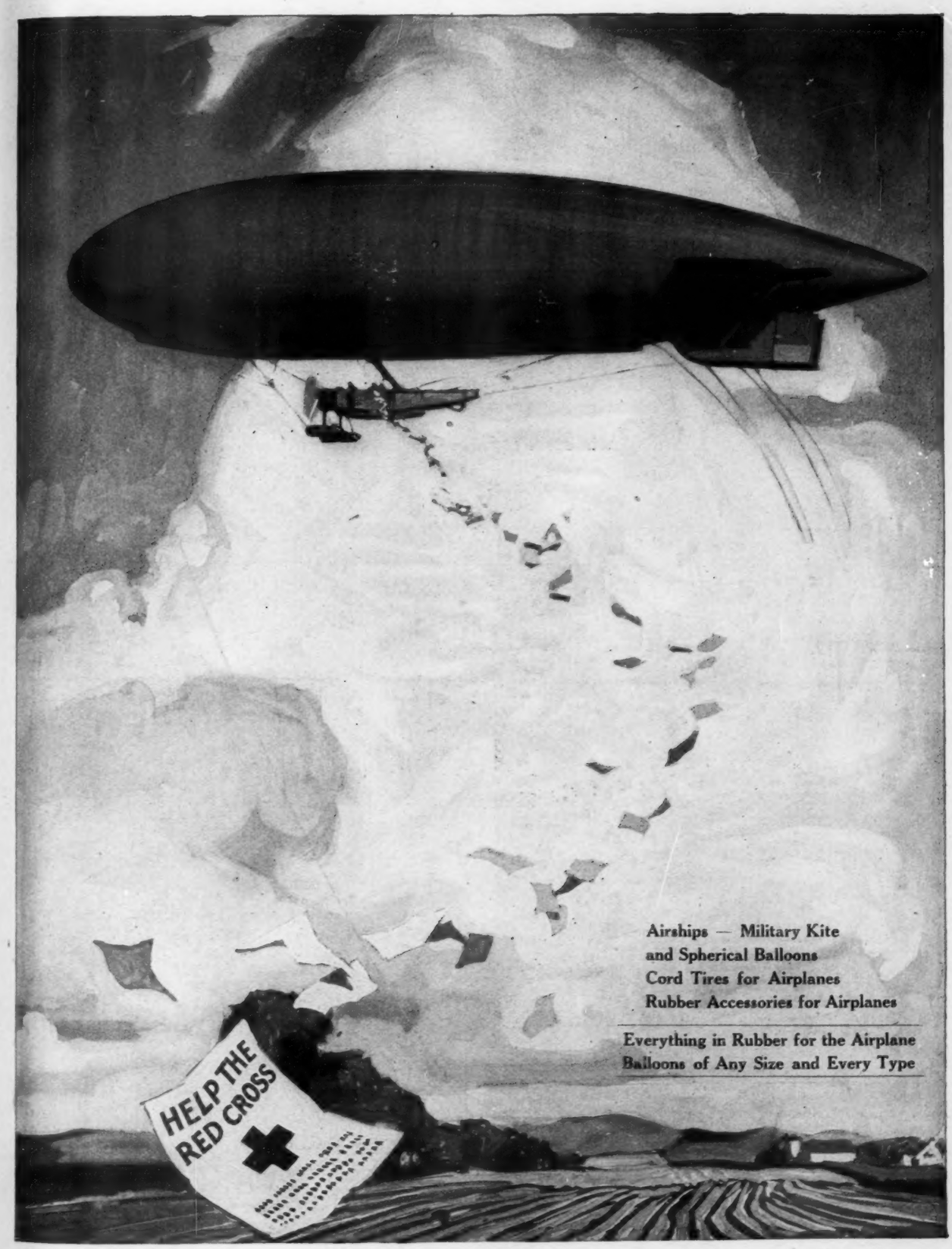
Then shave with short slanting strokes. It doesn't require any brute force to shave with a Gillette—the razor does the work.

Gillette Safety Razor, Ltd.
200 Great Portland St.
London, W., England

A. G. Micheles
53 Liteiny, Petrograd, Russia

Vedova Tosi Quirino & Figli
Via Senato, 18
Milan, Italy

Gillette Safety Razor Company
Boston Mass·U·S·A·



Airships — Military Kite and Spherical Balloons
Cord Tires for Airplanes
Rubber Accessories for Airplanes

Everything in Rubber for the Airplane
Balloons of Any Size and Every Type

GOODYEAR
AKRON

Thomas

THOMAS-MORSE AIRCRAFT CORPORATION

ITHACA, N.Y. U.S.A.

Contractors to U. S. Government

WITTEMANN-LEWIS AIRCRAFT COMPANY

NEWARK, N. J.

Main Office and Factory:

Lincoln Highway
near Passaic River

Telephone, Market 9096

ERIE STANDARD
AIRCRAFT METAL PARTS
DEPENDABLE SERVICE
QUANTITY-PRODUCTION
Our plant at Erie—the largest of its kind—specializes on AIRCRAFT BOLTS, NUTS and CLEVIS PINS conforming to Government Specifications.
A product as near 100% perfect in quality and machine practice as the human element will permit.
Please request our New York Office to send you copy of our catalogue.
ERIE SPECIALTY COMPANY.
8 West 40th St., New York City
Main Plant Erie, Pa.

The HOLBROOK Co

New York City

MANUFACTURERS

Airplane Propellers
Airplane Sheet Aluminum Parts
Airplane Sheet Metal Parts
Airplane Woodwork
Airplane Upholstery

WE USE THE CELEBRATED

LUMA Radium Luminous Compound

Visible in the Dark

Our dial painting factories are splendidly equipped for service of the highest character.

Manufacturers of watches and clocks who entrust this important work to us are assured of perfect and unvarying results at minimum cost.

We use the celebrated Luma which is absolutely guaranteed to contain only Radium as its activating agent, no Mesothorium, Radiothorium, Ionium nor Polonium being added.

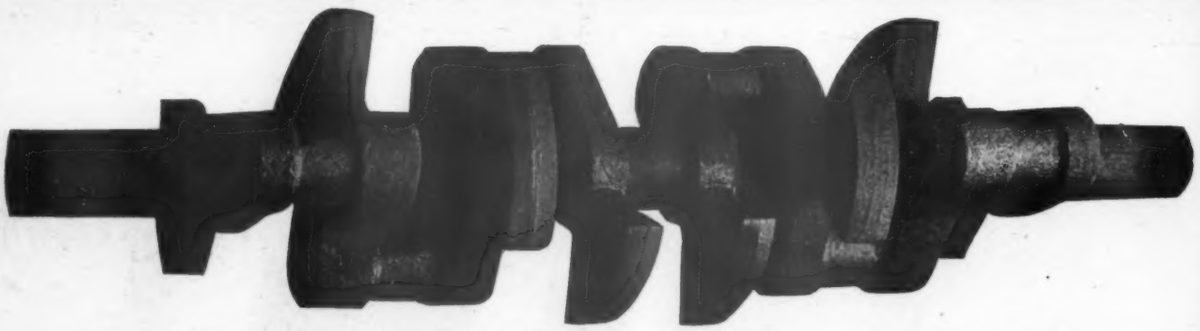
Write for full information.

RADIUM DIAL COMPANY

GENERAL OFFICES - PITTSBURGH, PA.

501 FIFTH AVE. NEW YORK – MARSHALL-FIELD ANNEX BLDG. CHICAGO.

DIAL PAINTING FACTORIES, PITTSBURGH, LONG ISLAND CITY, N.Y., CHICAGO.



a counterbalanced aviation crankshaft . . . .

Patented July 10th, 1917

one of the 18 different
models we are now making
for 14 aviation motor companies . . .
reduces vibration and eliminates bearing pressure

We have shipped 63,771 Counterbalanced Crankshafts to July 24, 1918

THE PARK DROP FORGE CO. CLEVELAND, OHIO

P. PRYIBIL MACHINE COMPANY

MANUFACTURERS OF

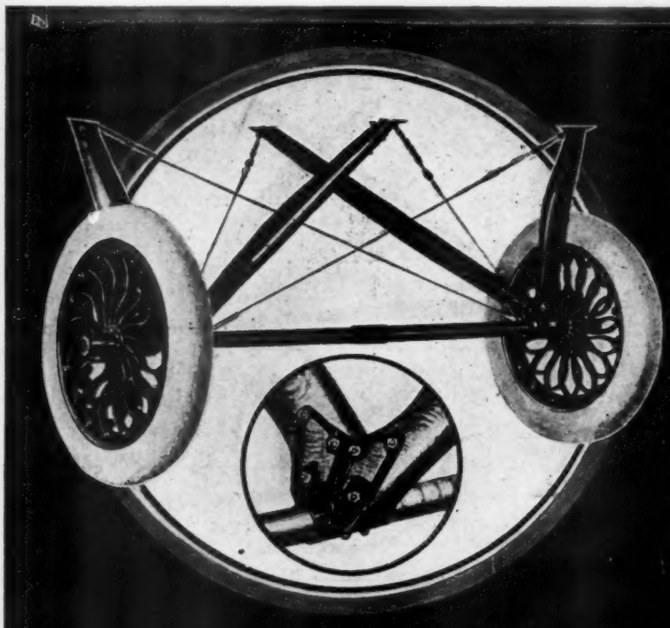
FINE WOOD WORKING MACHINES

WE HAVE SERVED

CURTISS ENGINEERING CORPORATION
L. W. F. ENGINEERING COMPANY
WRIGHT-MARTIN AIRCRAFT CORPORATION
STANDARD AIRCRAFT CORPORATION
CONTINENTAL AIRCRAFT COMPANY

Why not you?

Factory, 512-524 West 41st Street, New York City
Established 1862



ACKERMAN LANDING GEAR

Is the latest and highest development in the construction of Landing Gear

Their
SIMPLICITY
STRENGTH
and SERVICE
make them the logical equipment for the Modern Airplane.

Weight 96 pounds complete with tires built for craft weighing 2500 pounds

WHEELS and LANDING GEARS built for any size machine

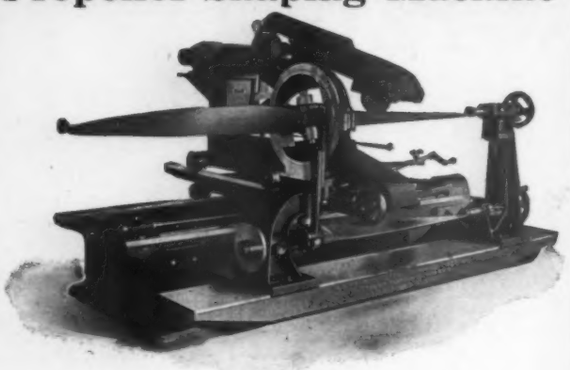
Complete data on Ackerman Equipment available for Designers and Engineers.

THE ACKERMAN WHEEL COMPANY

542 Rockefeller Building, CLEVELAND, OHIO, U.S.A.

MATTISON

Propeller Shaping Machine



For Two, Three and Four-Bladed Screws

A brand new machine—designed and built with the thoroughness characteristic of all Mattison woodworking machines—which has been approved by many of America's largest propeller manufacturers.

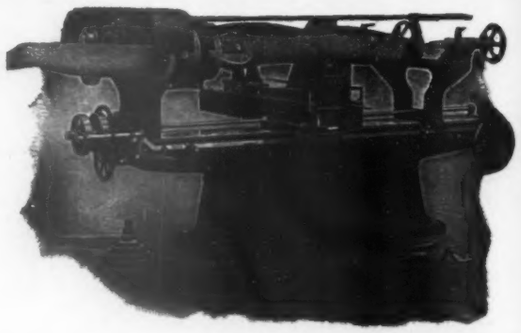
It works close to finish-size, thereby eliminating the greater part of the expensive hand work which usually follows the machining operation of other methods.

Write or Wire for Details

MATTISON MACHINE WORKS

879 FIFTH STREET BELOIT, WISCONSIN

THE DEFIANCE AUTOMATIC AIRPLANE PROPELLER LATHE



IT HAS GOVERNMENT AND MANUFACTURERS' ENDORSEMENTS

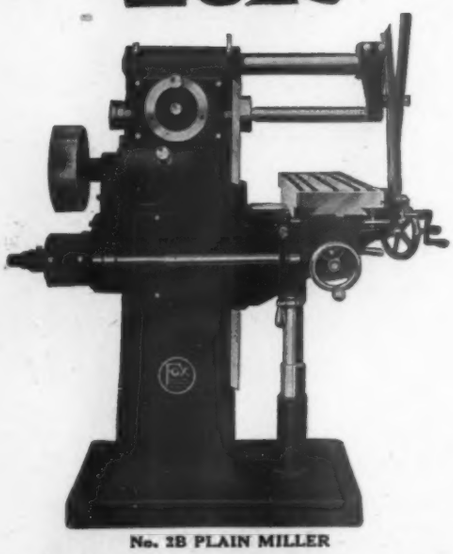
The proof of this lies in its use in England, in Italy, in Canada; its use in United States Government Arsenals, and fifteen of the leading propeller factories in America. Each machine in use releases from eight to ten skilled workmen for other duties. With one man operating a number of machines, the cost of working propeller blades close to size is reduced to a minimum. It automatically turns propeller blades of various sizes to any shape or pitch, and it will duplicate struts of irregular shape in facsimiles. Write for our circular which illustrates and describes this machine.

THE DEFIANCE MACHINE WORKS

DEFIANCE, OHIO, U. S. A.

NEW YORK *LONDON*

FOX



No. 2B PLAIN MILLER

Single Pulley Drive

12 changes to spindle speeds
6 changes to each spindle speed
No. 9 taper in spindle.
Table 8½ x 37"

Hardened machine steel gears throughout insure maximum driving power at all speeds.

We also build Universal Millers, Dividing Heads, Vertical Attachments and Vises.

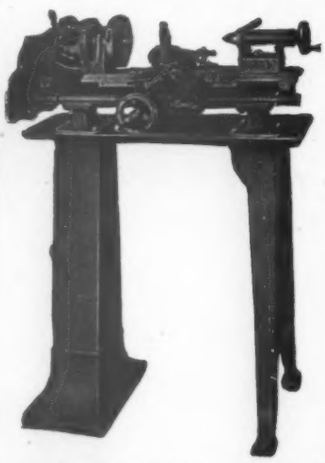
Write for Circular

THE FOX MACHINE COMPANY

1810 W. Gavson St:, Jackson, Mich.

Formerly of Grand Rapids, Mich.

"DALTON SIX"



In the Manufacture of Aeroplanes or the many small parts comprising a Unit

"Dalton Six"

is indispensable.

Furnished for English or Metric Thread Cutting.

One Manufacturer of fine instruments for aeroplanes now has

(36) "DALTON SIXES" Installed

Why Not Investigate?

BULLETIN B602C GIVES DETAILS

Dalton Manufacturing Corp.

Successors to Dalton Mach. Co., Inc.

1911 Park Avenue New York, U. S. A.

Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of companies listed below.

Names of Advertisers in this issue are printed in capitals.

See Index to Advertisers on page 200

ACCESSORIES AND INSTRUMENTS

Advance Felt Specialty & Cutting Co.
International Aeronautical Instrument Corp.
JOHNS-MANVILLE, H. W., CO.
King, Julius, Optical Co.
THE MOTO-METER CO.
National Gauge & Equipment Co.
Nelson Blower & Furnace Co.
O'Hara Waltham Dial Co.
Queen-Gray Co.
Rieker, Walter.
SPERRY GYROSCOPE CO.
Standard Aeronautical Co.
Stewart-Warner Speedometer Corp.
TAYLOR INSTRUMENT COMPANIES
Veeder Mfg. Co.
Western Electric Co.

AIRPLANES

Aeromarine Plane and Motor Co.
Blackhawk Airplane Co.
Blanchard-Radley Aircraft Co.
BOEING AIRPLANE CO.
Breese Aircraft Corp.
THE BURGESS COMPANY.
California Aviation Co.
Continental Aircraft Corp.
CURTISS AEROPLANE & MOTOR CORP.
Dayton Wright Airplane Co.
Des Lauriers Aircraft Corp.
Dewey Aeroplane Co.
Engel Aircraft Co.
Fisher Body Corp.
Fowler Airplane Corp.
Gallaudet Aircraft Corp.
Heinrich, A. S., Corp.
Lanzius Aircraft Co.
Lawrence-Lewis Aeroplane Co.
Lawson Aircraft Corp.
Lewis & Vought Corp.
Lanzius Aeronautical Eng. Corp.
Loagren Aeroplane Co.
L. W. F. ENGINEERING CO.
Martin Aeroplane Factory
MARTIN, GLENN L., CO.
Michigan Aircraft Corp.
Ordnance Eng'ring Corp.
Patterson Aeroplane Co.
Peirce, Sam'l S., Aeroplane Corp.
Smith, Kyle, Aircraft Co.
Sperry, Lawrence, Aircraft Co.
Springfield Airplane Co.
STANDARD AIRCRAFT CORP.
Sturtevant Aeroplane Co.
THOMAS-MORSE AIRCRAFT CORP.
The Willys-Morrow Co.
WITTEMANN-LEWIS AIRCRAFT CO.
Whittemore-Hamm Co.
WRIGHT-MARTIN AIRCRAFT CORP.

AIRPLANE ENGINES

Aeromarine Plane and Motor Co.
Ashmusen Mfg. Co.
Continental Motors Co.
CURTISS AEROPLANE & MOTOR CORP.
Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP.
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
HALL-SCOTT MOTOR CAR CO.
Kemp Machine Works.
Kessler Motor Co.
Knox Motors Co.
Nordyke & Marmon.
Packard Motor Co.
Roberts Motor Mfg. Co.
Rolls-Royce, Ltd.
Springfield Motors Co.
Sterling Engine Co.
Sturtevant, B. F., Co.
Trego Motors Corp.
THOMAS-MORSE AIRCRAFT CORP.
UNION GAS ENGINE CO.
Van Blerck Motor Co.
Willys-Overland Co.
WISCONSIN MOTOR MFG. CO.
World's Motor Co.
WRIGHT-MARTIN AIRCRAFT CORP.

AIRPLANE PARTS

Aircraft Parts Mfg. Co.
American Body Co.
Astoria Veneer Mill & Dock Co.
BARCALO MFG. CO.
Century Telephone Construction Co.
Chicago Aeronautical Supply Co.
DAYTON METAL PRODUCTS CO.
ERIE SPECIALTY CO.
GENERAL BAKELITE CO.
HOLBROOK CO.
Kawneer Mfg. Co.
Levett, Walker M., Co.
New Jersey Veneer Co.
Pressed & Welded Steel Products Co.
Rogers Construction Co.
Standard Parts Co.
Welch Mfg. Co.
Whittemore-Hamm Co.
WIDMAN, J. C., & CO.
Willys-Morrow Co.
Wilson Cabinet Co.

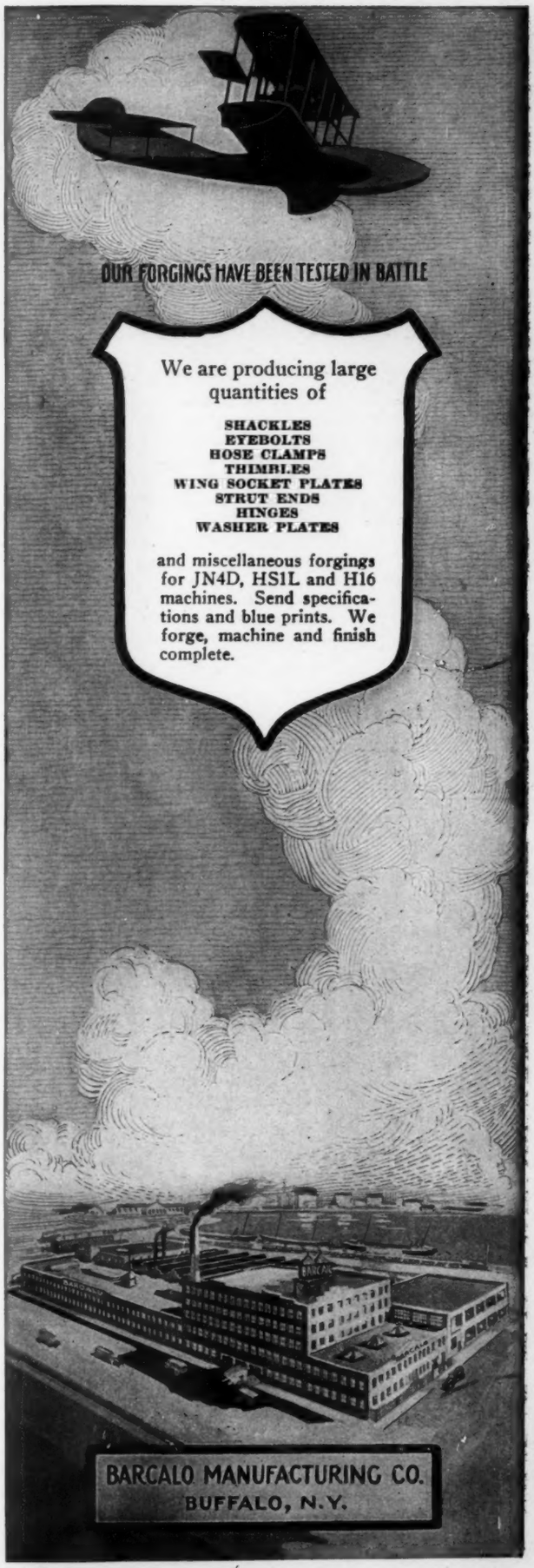
ALUMINUM

Acieral Co. of America
ALUMINUM CASTINGS CO.
ALUMINUM CO. OF AMERICA
American Metal Co., Ltd.
Levett, Walker M., Co.
Leygrand & Co.
McAdamite-Aluminum Co.
SO-LUMINUM MFG. & ENG. CO. (SOLDER)
STIMPSON, EDWIN B., CO.
United Smelting & Aluminum Co.

AVIATION SCHOOLS

American School of Aviation
America Trans-Oceanic Co.
Atlantic Coast Aeronautical Station
Beam Airplane Co.
Blackhawk Airplane Co.
Curtiss Training Schools
EAGLE AVIATION SCHOOL
The Hydrerocraft Co.
Michigan State Auto School
Moler Aviation Instructors
Penn. State School of Aero-Mechanics
Stinson School of Aviation
Whittemore-Hamm Co.

(Continued on page 189)



YALE
HOISTING HINTS

Yale Spur-Geared Blocks are efficiently meeting war-time emergencies.

They are increasing production, saving men and time.

The simplicity, rugged construction, speed and *safety* of Yale Spur-Geared Blocks make them indispensable for war work.

For hoisting under all conditions.

For factory locking equipment use a Yale Master-Key System. Write for particulars.

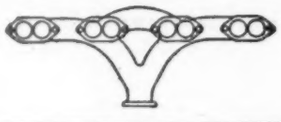
For Sale by Machinery Supply Houses

Put Your Hoisting Problems Up to Us

Yale Spur-Geared Block

The Yale & Towne Mfg. Co.
9 East 40th Street New York

AJAX Auto and Aero Sheet Metal Company
Manufacturers and designers of
AERO RADIATORS INTAKE and EXHAUST PIPES
H. W. MEYER, 245 West Fifty-fifth Street, New York



Johns-Manville
Aeronautic Instruments

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

OUR designing staff and manufacturing organization are both at the call of those who require *speed indicating* and *revolution recording* instruments.

We invite your special problems in airplane accessory apparatus.

H. W. Johns-Manville Co.
New York City

10 Factories. Branches in 60 Cities

"Flexo" Aero RADIATORS

The only core that will stand severe landing shocks.

No sharp corners to crystallize through vibration.

The only core that can be so bent without injury to the metal or soldered joints.

"FLEXO"—PATENTED

FLEXO MANUFACTURING CO.
1312-1320 E. 12th STREET LOS ANGELES, CAL.

Aeronautical Trade Directory—*Continued*

BALL BEARINGS
THE FAFNIR BEARING CO.
GURNEY BALL BEARING CO.
HESS-BRIGHT MFG. CO.
NEW DEPARTURE MFG. CO.
Norma Company of America
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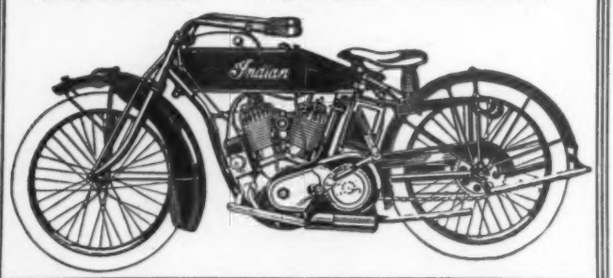

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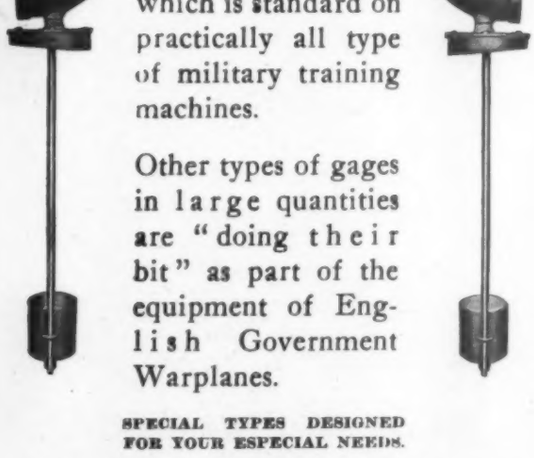

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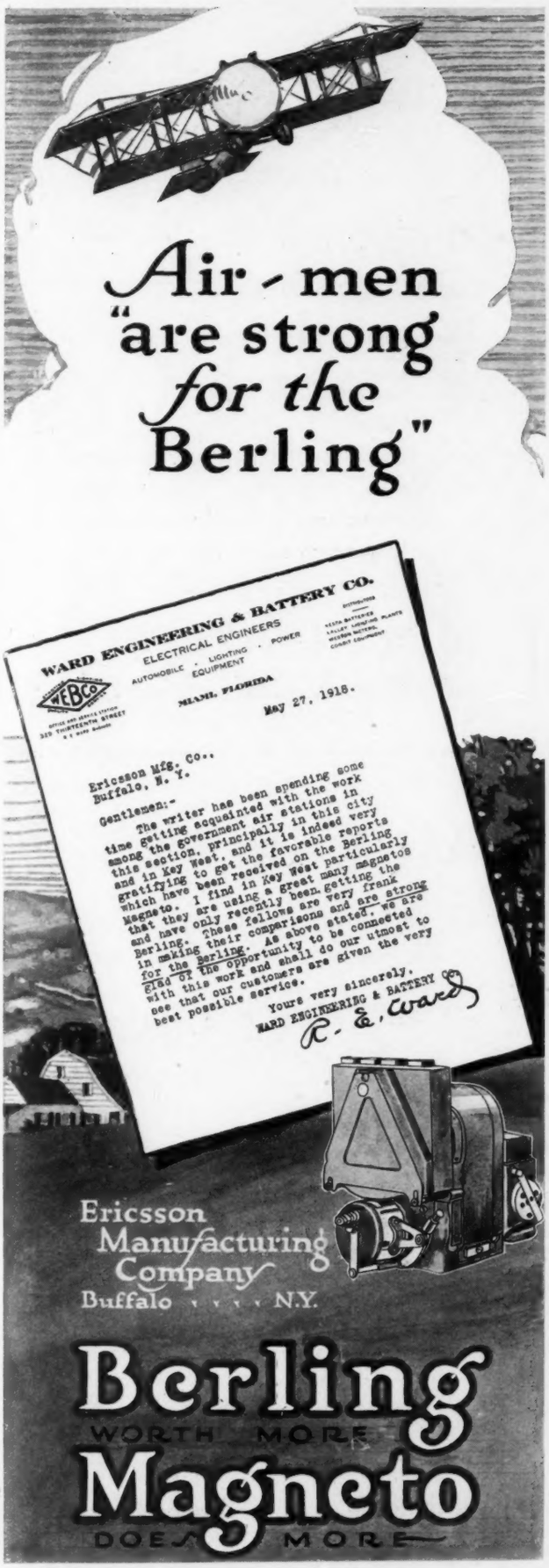
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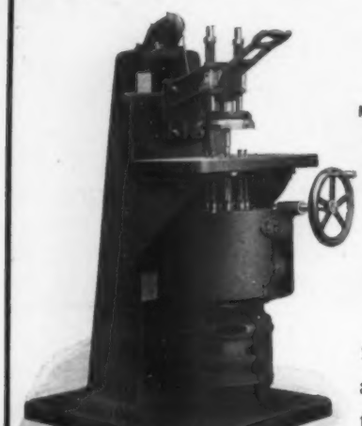

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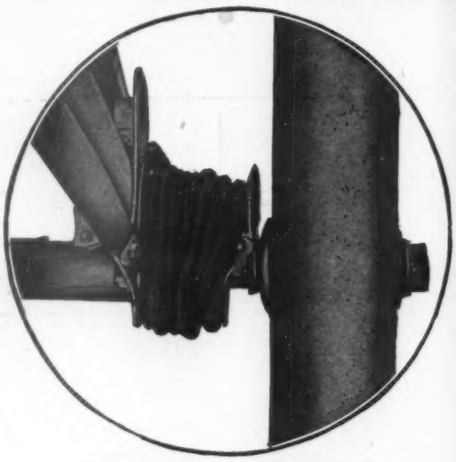

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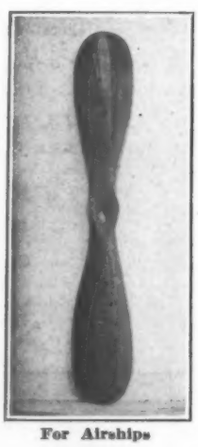
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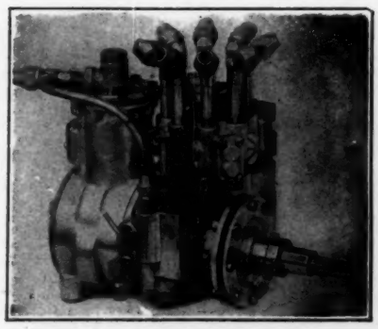

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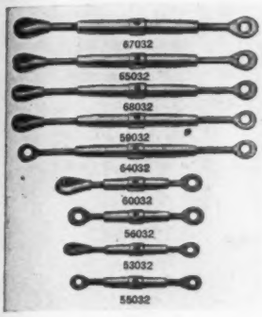

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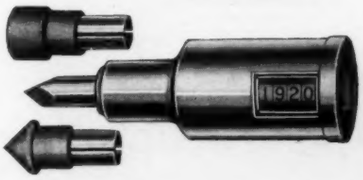

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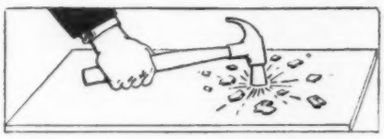
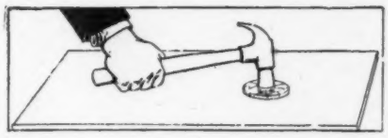


TEST NO. 1—Break any piece of any other kind of glass with a single hammer-blow. Note result. Some of the glass particles may remain in the rim, but what happens to your eyes from the particles that fly?



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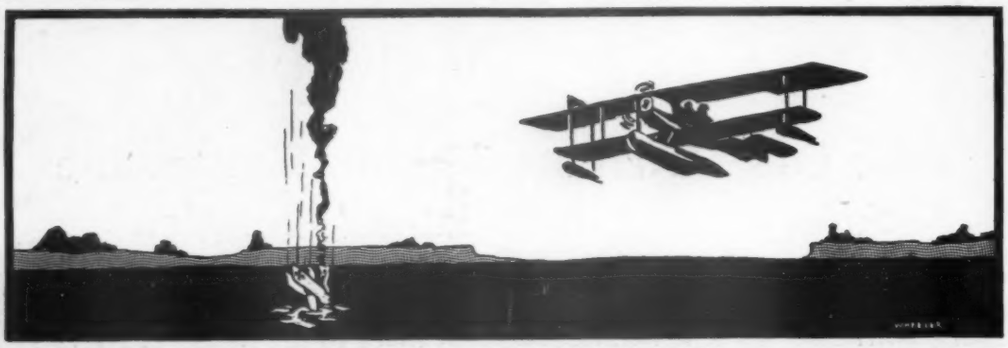

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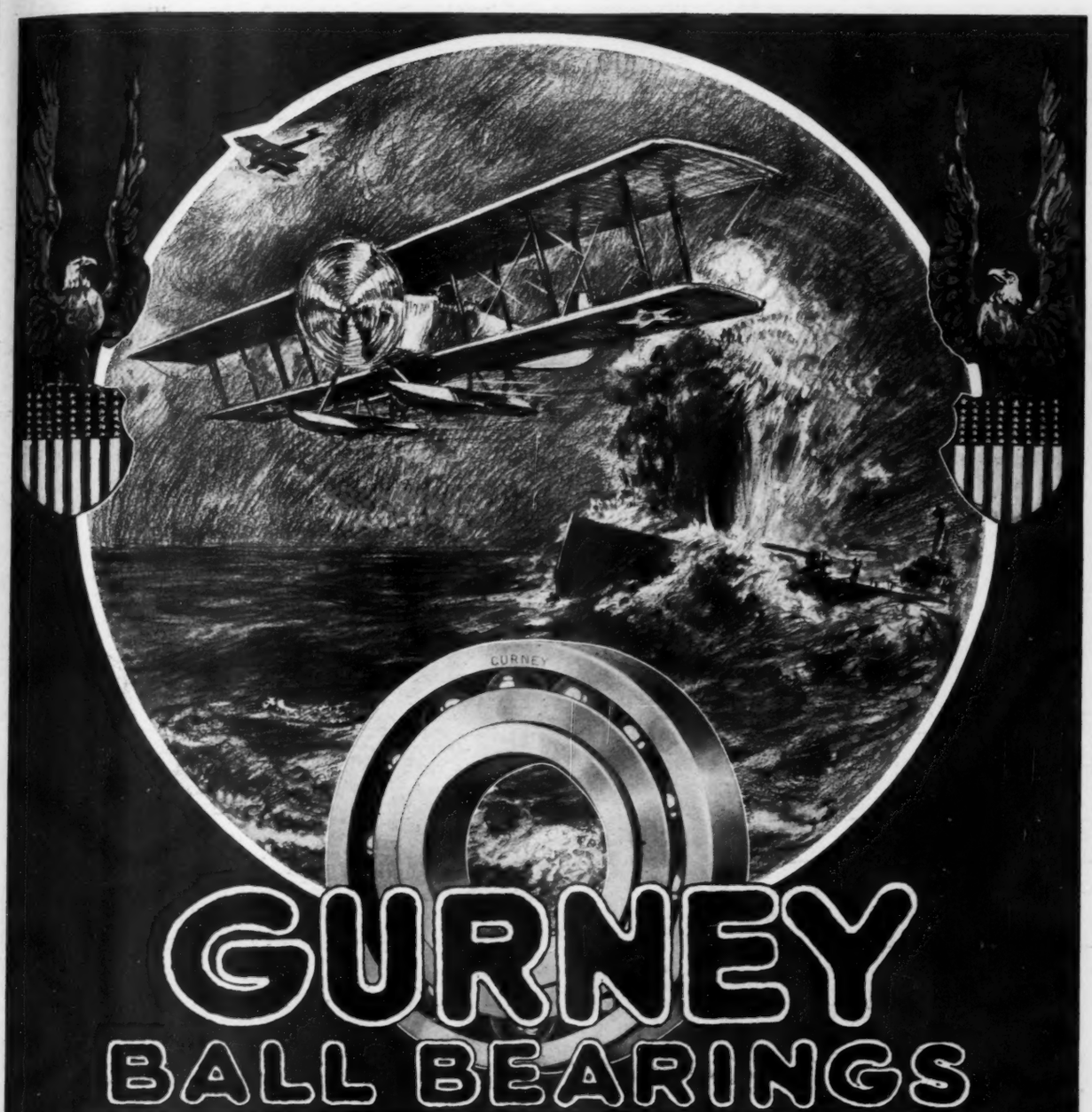

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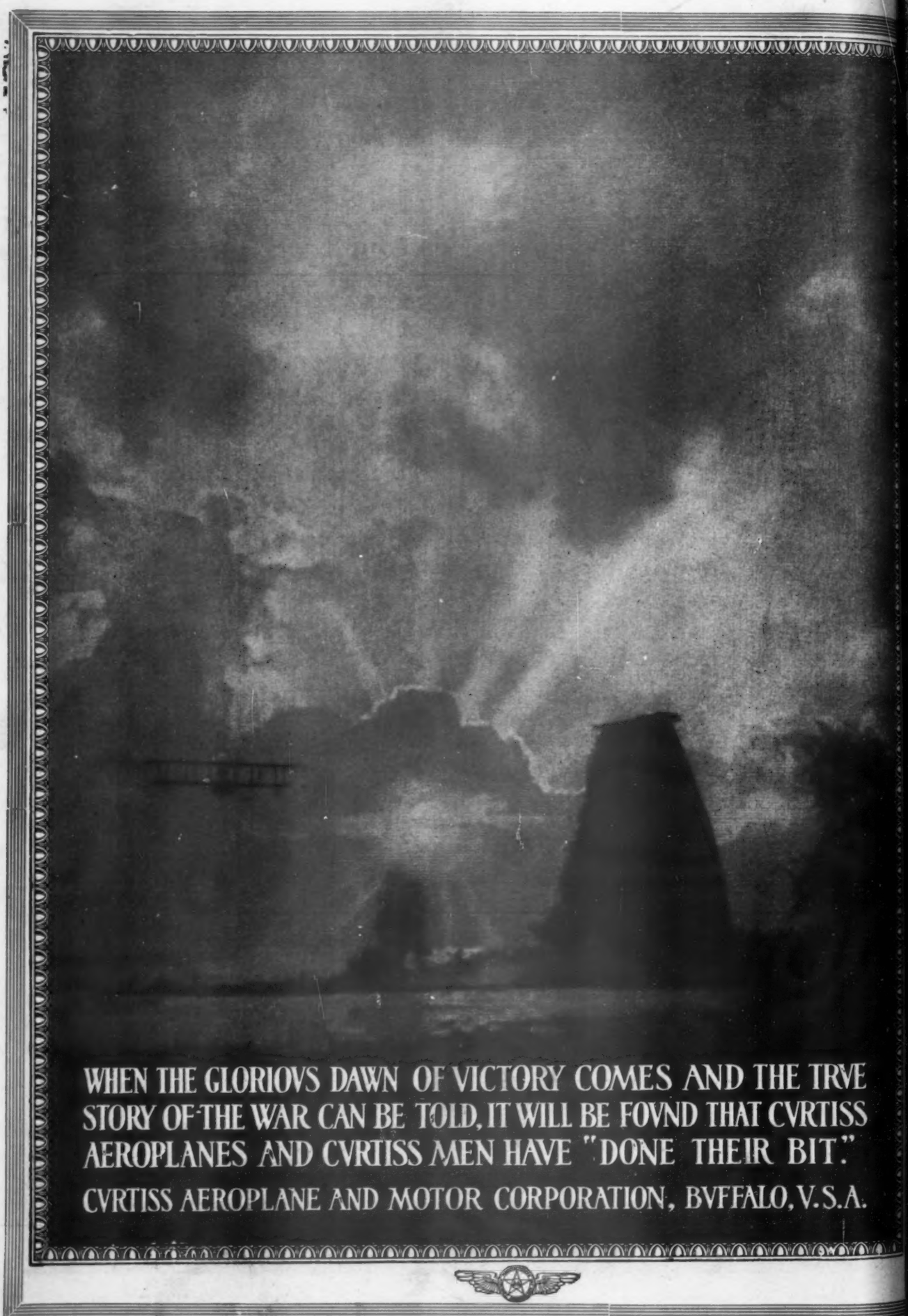
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